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ABSTRACT

A number of activities designed to develop each of six concepts listed for each of six conceptual schemes are presented. The conceptual schemes are: (1) Matter may be transformed; under ordinary (classroom-laboratory) conditions it is not created or destroyed; (2) Energy may be transformed; under ordinary conditions it is not created or destroyed; (3) Living things interchange matter and energy with the environment (and with other living things); (4) A living thing is the product of its heredity and environment; (5) Living things are in constant change; and (6) The universe is in constant change. Most activities can be performed by students, although some are intended as teacher demonstrations. Questions to guide discussion are included for each activity; all contain references to texts which are listed in an appended bibliography. [Not available in hardcopy due to marginal legibility of original document.] (AL)

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TENTATIVE
CURRICULUM GUIDE
JUNIOR HIGH SCHOOLS

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SCIENCE
VOLUME IV

Board of Education
of St. Mary's County
Leonardtown, Maryland

1967

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Tentative

SCIENCE CURRICULUM GUIDE

Grades 7 - 8

BOARD OF EDUCATION
OF ST. MARY'S COUNTY

Leonardtown, Maryland

1967

FOREWORD

Since September, 1960, committees composed of teachers, principals, and supervisors have been working to develop curriculum guides in science for use in the elementary and junior high schools of St. Mary's County. This tentative curriculum guide for the teaching of science in grades seven and eight completes the eight levels of the planned program.

The structure of the St. Mary's County science program through grade eight is based on a framework of six conceptual schemes first proposed by Dr. Paul F. Brandwein in "The Burton Lecture: Elements in a Strategy for Teaching Science in the Elementary School," given at Harvard University in 1961. Concept levels in each scheme have been established through which students can advance to an understanding of the entire scheme.

Within the various disciplines of science, data accumulate and change at such a rate that change in content is constant. The conceptual scheme structure continues to give content a strong and relevant place but suggests a way to accommodate its diversity. The concepts do not change, thus offering a way to provide a degree of stability and continuity in teaching science.

It is hoped that this guide for grades seven and eight will offer to teachers assistance in knowing what to teach and how to teach it, yet allow for individual creativity in its flexibility. It is hoped further that teachers, as they use the guide, will contribute their suggestions for improving it in the revision planned for the summer of 1968.

Robert E. King, Jr.
Superintendent of Schools

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PREFACE TO THE TEACHER

The St. Mary's County science curriculum for grades one through eight is based upon six major conceptual schemes. These schemes, or families of ideas, embrace the areas of both physical and biological science. Curriculum guides for teachers place major emphasis in teaching and learning on inquiry, and include observation, investigation, interpretation, and research of appropriate literature as learning activities.

This fourth volume of the guide is intended to be used in grades seven and eight, though it could be adapted to include the sixth grade and could be used also with particular groups of students at other grade levels. Each activity could be varied to adapt it for use with students of varying levels of ability.

Teachers should by no means assume that the guide alone comprises an adequate curriculum in general science. Rather, it is to serve as the structure on which to build the curriculum and suggest content and method for teaching general science in the upper middle grades.

The activities included in the guide should be used in developing, with students, learnings inherent in the concepts assigned to each grade level. It is requested that teachers evaluate each activity as it is used and recommend any changes deemed necessary. This should include deletions as well as any additional activities developed by the teacher that prove to be of value in helping students uncover concepts. These will be of invaluable assistance in revising the guide during the summer of 1968.

Activities designed to develop the first three concepts in each conceptual scheme are printed on white paper and are intended to be explored in the seventh grade. Activities for the fourth, fifth, and sixth concepts in each scheme appear on yellow pages and are intended to be used in the eighth grade.

All investigations, unless otherwise indicated, should be conducted by the students themselves, working independently or in groups. The role of the teacher is intended to be one of giving direction and assisting students in learning by means of skillful questioning - not by dispensing information. The student must have the opportunity to uncover concepts himself - through observation, investigation, interpretation, and research. In the process, he will develop the knowledges and understandings, the attitudes, and the skills which are the objectives of science instruction.

Conceptual Scheme A

MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

A-1 - Concept I (Analogical)

Matter exists in various phases.

A-2 - Concept II (Analogical)

The phases of matter can be changed.

A-3 - Concept III

Matter exists in small particles.

A-4 - Concept IV

Matter consists of elements and compounds.

A-5 - Concept V

In a reaction, the totality of matter remains constant.

A-6 - Concept VI

With extraordinary (uncommon) methods matter can be destroyed to release energy.*

***The total sum of matter - energy is conserved.**
See B-6.

Conceptual Scheme B

ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED. (*)

B-1 - Concept I (Analogical)

Energy must be used to set an object in motion.

B-2 - Concept II (Analogical)

There are different forms of energy.

B-3 - Concept III

Energy can be changed from one form to another.

B-4 - Concept IV

Molecular motion (kinetic energy) can be altered by the absorption or release of energy.

B-5 - Concept V

Once an object is in motion, it tends to remain in motion, unless energy is used to produce an unbalanced force.

B-6 - Concept VI

Energy gotten out of a machine does not exceed the energy put into it.

*Total sum of matter and energy is conserved. (A-6) (Conservation of Mass - Energy)

Conceptual Scheme C

LIVING THINGS INTERCHANGE MATTER
AND ENERGY WITH THE ENVIRONMENT
(AND WITH OTHER LIVING THINGS).

C-1 - Concept I (Analogical)

All living things are affected by their environment.

C-2 - Concept II (Analogical)

All living things depend on the environment for the conditions of life.

C-3 - Concept III

There are characteristic environments each with their characteristic life.

C-4 - Concept IV

Living things capture matter from the environment and return it to the environment.

C-5 - Concept V

The capture of radiant energy by green plants is basic to the maintenance and growth of all living things.

C-6 - Concept VI

Living things are adapted in structure and function to the environment.

Conceptual Scheme D

A LIVING THING IS THE PRODUCT
OF ITS HEREDITY AND ENVIRONMENT.

D-1 - Concept I (Analogical)

Living things are produced only from other living things.

D-2 - Concept II (Analogical)

Living things reproduce by different sexual and asexual means.

D-3 - Concept III

A living thing reproduces itself and develops in a given environment.

D-4 - Concept IV

The cell is the unit of structure and function; a living thing develops from a single cell.

D-5 - Concept V

The characteristics of a living thing are laid down in a genetic code.

D-6 - Concept VI

The expression of hereditary traits is influenced by the environment.

Conceptual Scheme E

LIVING THINGS ARE IN CONSTANT CHANGE.

E-1 - Concept I (Analogical)

There are different forms of living things.

E-2 - Concept II (Analogical)

There are extinct forms of living things.

E-3 - Concept III

Living things can be classified according to structure.

E-4 - Concept IV

The environments of living things have changed over the ages.

E-5 - Concept V

Living things have changed over the ages.

E-6 - Concept VI

Changes in the genetic code produce changes in living things.

Conceptual Scheme F

THE UNIVERSE IS IN CONSTANT CHANGE.

F-1 - Concept I (Analogical)

There are daily changes on Earth.

F-2 - Concept II (Analogical)

There are regular movements of the Earth and Sun.

F-3 - Concept III

Seasonal and annual changes on Earth and within the solar system can be predicted.

F-4 - Concept IV

Universal gravitation and in inertial motion govern the relations of all celestial bodies.

F-5 - Concept V

Changes on Earth, erosion and and land building occur in predictable sequence.

F-6 - Concept VI

Nuclear reactions produce the radiant energy of stars.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter exists in various phases.

Title: Density as a property of matter

ACTIVITY	QUESTIONS
Materials: two boxes of same size as cigar boxes, sand, vermiculite, balance	
Before class begins, fill one of the boxes with sand, the second with vermiculite, and seal both with tape.	What are the volumes of these two boxes?
Allow each group of students to measure each box and determine its volume.	
Have each group weigh each box.	What did you find to be true of the volume of the boxes? What did you find to be true of the weights of the boxes? What might be the reasons for the difference in weight?
List all reasons on board.	Which box contains more matter?
Have students open boxes and observe.	What do you observe about the contents of the two boxes? How can we increase the weight of the box of vermiculite? What must we do to get more vermiculite in the same volume?
Have students pack down the vermiculite and add more. Reweigh	What did you do to the particles of vermiculite when you packed them down? What factor did not change? What factor did change? What caused this increase in weight?
Discussion should develop the concept of density.	How does adding more vermiculite to same volume cause an increase in weight?

Summary Statement: The amount of matter per unit volume is called density.

Concept Term: density

Auxiliary Words: volume, weight

References:

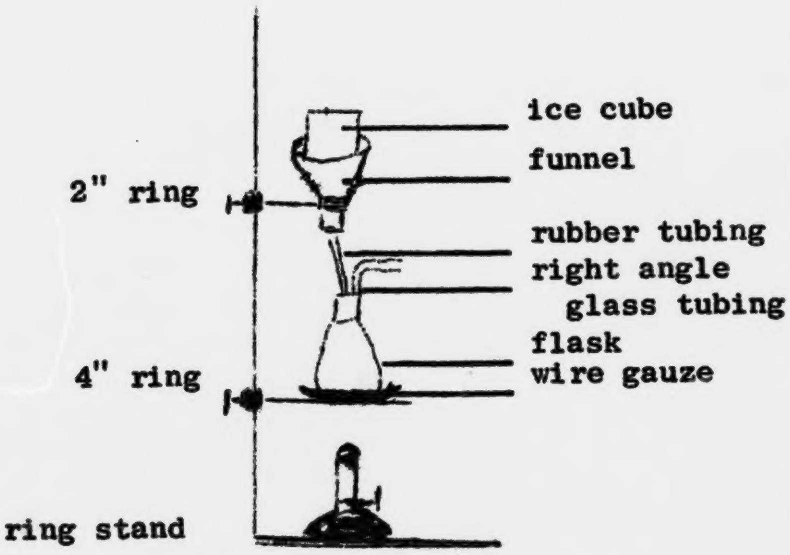
Jacobson, Willard J., et al., Challenges in Science. New York: American Book Company, 1961.

Heimler, Charles, et al., Principles of Science. Columbus: Charles Merrill Books, Inc., 1966.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter exists in various phases.

Title: Phases and molecular attraction

ACTIVITY	QUESTIONS
Materials needed: funnel, ringstand, rubber tubing, two-hole rubber stopper, two right-angle glass tubes, flask, one 2" ring, one 4" ring, wire gauze, heat source, ice cubes Set up apparatus as follows:  ice cube funnel 2" ring rubber tubing right angle glass tubing flask wire gauze 4" ring ring stand	
Place ice cube in funnel.	What do you expect will happen? Why won't the ice cube go through the funnel? Why will an equal volume of water go through the funnel? What is the difference between a liquid and a solid? What do you know about the speed of molecules in a solid? What, then, keeps the solid from evaporating immediately?

	What might you assume is true of the attraction between these molecules?
Ice should be melting.	How does the attraction between molecules of water compare to those of ice? How do you know? What will happen to the water when it is heated?
Heat flask gently.	What will happen to the speed of the molecules? What will happen to the strength of the attraction between these molecules? How do you know?

Summary Statement: Molecular attraction is decreased as the speed of molecules is increased.

Auxiliary Term: molecular attraction

References: Marean, John H., Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Davis, Ira C., et al., Science 2, Experiment and Discovery. New York: Holt, Rinehart and Winston, Inc., 1965.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter exists in various phases.

Title: We determine volume

ACTIVITY	QUESTIONS
Materials: assortment of objects, such as stones, wooden blocks, small metal blocks, graduated cylinder, ruler	
Give each group of students an assortment of the above material.	What do all of these objects have in common?
Have each group of students center attention on the small metal block.	What are the properties of this block? How might we find the amount of space that this block of metal takes up?
Have each group determine the volume of the metal block.	How much water would your metal block hold if it were hollow? How else might you find the amount of space that this block takes up?
Discussion should move toward finding the volume of the metal block by displacement of water. (This can be done by gently sliding the metal block down the side of the graduated cylinder into water and determining the volume of water displaced.)	Why did the water rise when you inserted the metal block? How far did the water rise? How does this compare to the amount of space occupied by the block?

Summary Statement: Matter occupies space.

Concept Terms: volume, displacement

Reference: Marean, John H., Ledbetter, Elaine W., *Physical Science, A Laboratory Approach.* Reading: Addison-Wesley Publishing Company, 1968.

6.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter exists in various phases.

Title: Heat increases molecular motion

ACTIVITY	QUESTIONS
Materials needed: a small quantity of already popped popcorn, a large quantity of unpopped popcorn, a one liter beaker (or a large pyrex container) and a cover for the container. Mix a small quantity of unpopped popcorn and a quantity of popped popcorn to a depth of about one inch so that only the popped popcorn is noticeable. Each kernel of popped popcorn will be considered a molecule. Keep materials out of sight until called for.	What is matter?
Note: As this is an introductory lesson let the discussion develop fully.	What are the basic building blocks of matter? What are the phases (states) of matter?
Note: This guide uses the term "phase" rather than "state of matter".	What are some properties of each phase? What determines the phase of matter? (motion and arrangement of molecules)
Hold up the container of mixed popcorn.	If each piece of popped popcorn represents a molecule, what phase of matter might this represent? (solid) Why?
Cover the container and apply heat to start the popcorn popping.	What phase of matter could this represent if the lid is the surface? Why? (molecules in rapid motion with random arrangement and the matter takes form of container)
Remove the top and allow popcorn to pop out of the container. Note: You may have to start over if most or all of the popcorn has popped.	What phase of matter could this represent? Why?

Summary Statement: Heat may affect the motion and arrangement of molecules.

References:

Brandwein, Paul F., et al., *The World of Matter and Energy*. New York: Harcourt, Brace and World, 1964.

Schneider, Herman and Nina, *Science for Today and Tomorrow*. Boston: D. C. Heath Company, 1965.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: The phases of matter can be changed.

Title: Solid to liquid by heat

ACTIVITY	QUESTIONS
Have on hand ice cubes colored with dye (food coloring) and a glass container for each pupil.	
Hold up one of the colored ice cubes.	What phase of matter does this ice cube represent? What evidence do you see of molecular motion in this ice cube?
	What do you think will happen if this ice cube is placed in warm water? Why?
	What will happen to the water in the glass?
Pass out to each pupil an ice cube and a container of water. Instruct them to place their ice cubes in warm water and observe without disturbing the water, what happens. Have them write down what they see.	
After a reasonable observation period begin discussion of pupils' results.	Why did the water become colored in your glass?
	What caused the dye to disperse through the water in the glass?

Summary Statement: Increased motion of molecules due to absorption of heat may change a solid to a liquid.

References:

Brandwein, Paul F., et al., The World of Matter and Energy. New York: Harcourt, Brace and World, 1964.

Heimler, Charles, et al., Principles of Science. Columbus: Charles Merrill Books, Inc., 1966.

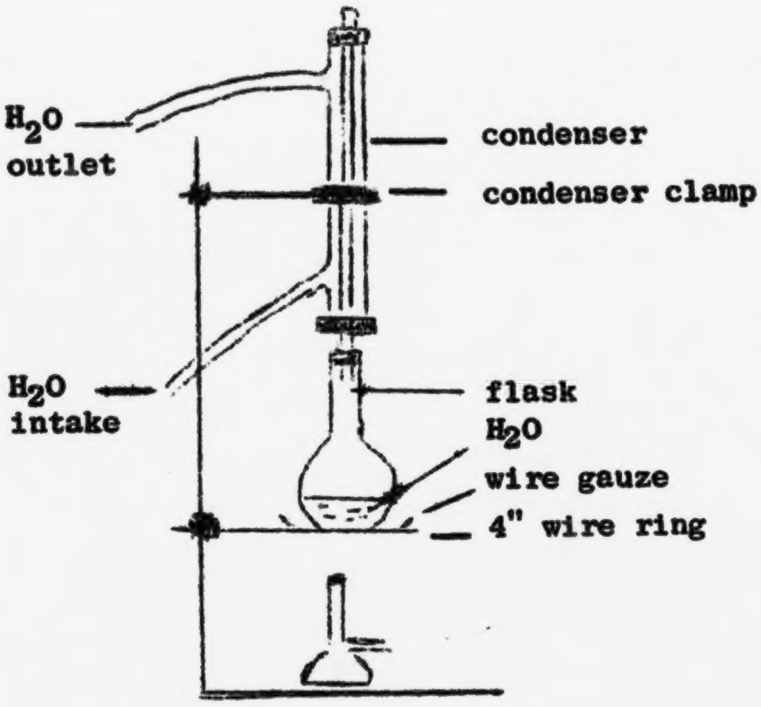
Jacobson, Willard J., et al., Challenges in Science. New York: American Book Company, 1961.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: The phases of matter can be changed.

Title: Liquid to-gas to-liquid by temperature change

<table>
<tr><th>ACTIVITY</th><th>QUESTIONS</th></tr>
<tr><td>
Set up the apparatus as follows:



</td><td></td></tr>
<tr><td>Heat the flask and have students observe.</td><td>
What will happen if we apply heat to the water?
Why?

What do you observe occurring in the condenser?
How can you explain this?
What is needed to change the liquid to a gas?
What is needed to change the gas back to a liquid?
</td></tr>
</table>

Summary Statement: A change in temperature which causes a change in molecular motion may cause a phase change.

Concept Terms: evaporation, condensing

Reference: Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

10.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: The phases of matter can be changed.

Title: Solid to gas by heat

ACTIVITY	QUESTIONS
Materials needed: deodorant blocks, balances.	
Pass out a piece of deodorant block to each student or each group of students. Have them observe the piece of block for a reasonable period of time. Instruct them to record their observations.	What are some of the properties of the deodorant block? Why were you able to detect an odor?
Have students weigh their pieces of deodorant blocks. Place in an open container in the room.	What do you think will happen if we leave this container here for several days? How might we find out?
Weigh the pieces of block daily and record the weights.	What happened to the pieces of deodorant block? How do you know? What is happening to the molecules of the deodorant block? In what phase do these molecules exist? What might we say is happening to the block? What is needed to cause the block to evaporate? Where did this heat come from? What other materials do you know of that change directly from a solid to a gas? What is this type of evaporation called?

Summary Statement: Increased motion of molecules due to absorption of heat may change a solid to a gas.

Concept Term: sublimation

References:

Heimler, Charles, et al., Principles of Science. Columbus: Charles Merrill Books, Inc., 1966.

Dull, Charles, et al., Modern Physics. New York: Holt, Rinehart and Winston, 1964.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: The phases of matter can be changed.

Title: Gas to solid by loss of heat

ACTIVITY	QUESTIONS
Have on hand small beakers or similar glass containers, watch glasses and iodine crystals, heat sources.	
Note: Iodine crystals and fumes are dangerous. The crystals should be handled with tongs and breathing of the fumes should be avoided.	
Have pupils examine some iodine crystals.	In what phase of matter do these crystals exist? Why are these crystals a solid rather than a liquid or gas? What could be done to change these solid crystals into a gas?
Have pupils or groups of pupils place iodine crystals in glass beakers, place a watch glass on top of each beaker, and begin heating very gently. Observe.	What happens to the crystals as you begin heating? Why? What happens to the gas when it comes into contact with the bottom of the watch glass? Why? What would have happened to the gas if the watch glass had not been covering the beakers? What must be removed from the molecules of a gas to change the gas to a solid?

Summary Statement: Decreasing the motion of molecules by taking away heat may change a gas to a solid.

References:

Dull, Charles, et al., Modern Chemistry. New York: Holt, Rinehart and Winston, 1962.

Bush, George L. and Thompson, Will S., World of Science. New York: American Book Company, 1959.

Mach, Edward, Jr., et al., Textbook of Chemistry. Second Edition. New York: Ginn and Company, 1956.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: The phases of matter can be changed.

Title: Gas to a solid

ACTIVITY	QUESTIONS
Materials needed: CO_2 fire extinguisher, large battery jar	
Note: Fire extinguishers for demonstrations may be obtained from the maintenance department. Cans of hair spray or spray paint would also have value in this activity.	What does this fire extinguisher contain?
Release a small amount of CO_2.	
Have students feel the nozzle of the extinguisher.	Why does the nozzle feel cold? Where did the heat energy go? Why?
Have students observe as CO_2 is released into the battery jar rapidly until solid CO_2 forms.	What do you observe in the battery jar? What might you assume the white substance to be?
Have students feel sides of battery jar.	Why is the battery jar cold? What caused the carbon dioxide to become a solid?

Summary Statement: Gas particles which are cooled sufficiently become a solid.

References:

Dull, Charles, et al., Modern Physics. New York: Holt, Rinehart and Winston, 1964.

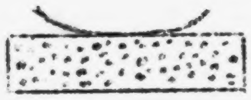
Jacobson, Willard J., et al., Adventures in Science. New York: American Book Company, 1964.

Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: The phases of matter can be changed.

Title: A liquid is changed to a solid

ACTIVITY	QUESTIONS
Materials needed: ether, watch glass, damp sponge	What happens to liquids if they are left out in the open air? What causes liquids to evaporate?
Have students place a drop of ether on their hands.	What happened to the ether? What do you feel on your hand? Why?
Have students place a watch glass containing ether on a wet sponge. 	What is happening to the ether? How can you tell? What will happen to the temperature of the watch glass? Why? What might happen to the liquid in the sponge?
Have students fan or blow air across the top of the ether.	Why did we fan the ether? As the ether evaporates faster, what happens to the temperature of the watch glass? Why?
After the ether has evaporated, have students observe the damp sponge upon which the watch glass was resting.	What happened to the liquid in the sponge? Why?

Summary Statement: Decreased motion of molecules due to loss of heat may cause a liquid to become a solid.

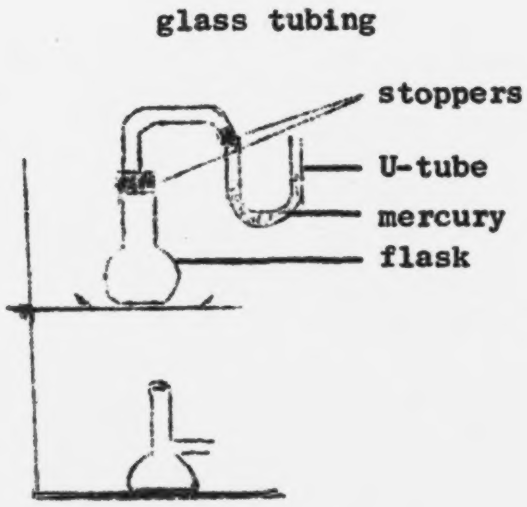
References: Davis, Ira C., et al., Science 2, Experiment and Discovery. New York: Holt, Rinehart and Winston, 1965.

Dull, Charles, et al., Modern Physics. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: The phases of matter can be changed.

Title: Heat and molecular motion

ACTIVITY	QUESTIONS
Materials: mercury, glass beads, beaker, heat source, flask, U-tube, glass tubing, ring stand Place a small amount of mercury in a beaker and cover with small glass beads. Heat gently until mercury boils.	What do you observe **happening** to the glass beads? What does this behavior indicate may be happening to the molecules of mercury? What form of energy brought about this motion? What might eventually happen to the mercury?
Set up apparatus as follows:  Heat flask of air gently.	What does the flask contain? What phase of matter is this? Of what small particles is this matter composed? What will happen to these molecules when I heat the flask? What happened to the mercury in the U-tube? What happened to the pressure in the flask?

	How do you know? What caused this?

Summary Statement: Molecular activity is increased with the application of heat.

Auxiliary Word: molecular pressure

References:

Boylan, Paul J., Elements of Physics. Rockleigh: Allyn and Bacon, Inc., 1962.

Brandwein, Paul F., The World of Matter and Energy. New York: Harcourt, Brace and World, 1964.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: The phases of matter can be changed.

Title: Pressure as a factor in phase change

ACTIVITY	QUESTIONS
Note to teacher: The following activity should be performed as a demonstration. Have available a vacuum pump, a bell jar or similar heavy-walled jar, a container of water and a heat source. Hold up the container of water for the pupils to observe.	What phase of matter is represented by the substance in this container? How might we most easily change this substance (liquid) to a gas?
Heat the container of water until it begins to boil.	Why does heating water cause it to become a gas? What will happen if we stop heating the water? Why?
Remove the heat source and carefully place the container of still-boiling water on the vacuum pump. Allow the water to stop bubbling (boiling) before placing the bell jar on the pump. When the boiling can no longer be observed place the bell jar on the pump, and operate to remove air. When enough air has been removed the water should resume boiling without again adding heat. Teachers may wish to allow water to cool below 100° C. and show this by measuring the temperature with a thermometer.	What happened to the container of water in the bell jar after we removed the air? What caused the water to boil again? What effect does pressure have on phase change? Why?
Optional Activity: Boil some water in an open, new or perfect, round bottomed flask. While the water is still boiling, tightly stopper the flask and invert it on a ringstand support. As soon as the	

boiling has stopped, pour cold water over the flask and observe the water boil again. Discuss results.

Research: The effects of pressure (or lack of it) on various phases of matter.

Summary Statement: A liquid may become a gas when the pressure is decreased.

Auxiliary Term: vacuum

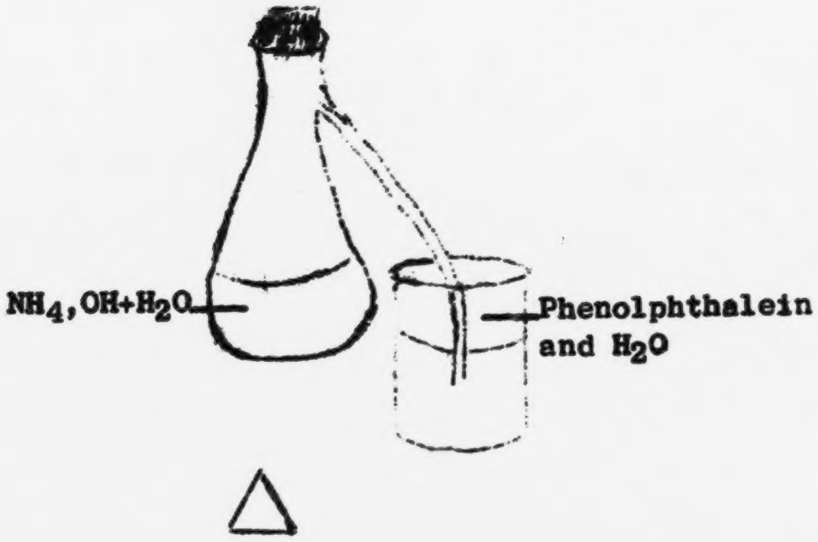
Reference: Jacobson, Willard J., et al., Adventures in Science. New York: American Book Company, 1964.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: The phases of matter can be changed.

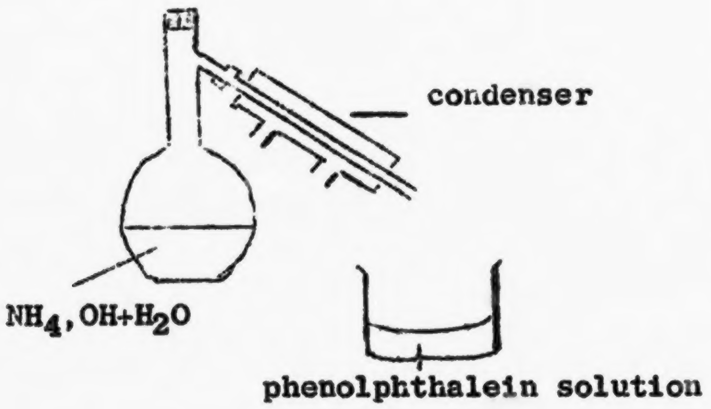
Title: Liquid to a gas to a liquid

ACTIVITY	QUESTIONS
Materials needed: Leibig Condenser, glass tubing, beakers, solution of water and concentrated ammonium hydroxide, a solution of water and phenolphthalein, dilute hydrochloric acid, distilling flask	
Set up two beakers, one of which contains hydrochloric acid and one of which contains ammonium hydroxide. Tell students that you have hydrochloric acid and ammonium hydroxide but not which beaker they are in.	Which beaker contains the acid? Which beaker contains the ammonium hydroxide?
Put a drop of phenolphthalein in each beaker and have students note odor cautiously.	What happened in the beaker which contains hydrochloric acid? What happened in the beaker which contains ammonium hydroxide? How is phenolphthalein helpful in finding out which beaker contains the ammonium hydroxide?
Set up apparatus as follows:	



Heat flask until the phenolphthalein solution turns pink, then stop.

Set up the Leibig Condenser and use the same solution of ammonium hydroxide and water and a new solution of phenolphthalein.



Why do you think the solution in the beaker turned pink?
How did the ammonia gas reach the collecting beaker?
What caused the ammonium hydroxide to change to a gas?
How can I change the gas back to a liquid?

What happened to the gas?
How do you know?

Summary Statement: The phase of matter can be changed by adding or removing heat.

References:

Baker, Philip S., et al., Chemistry and You. Chicago: Lyons and Carnahan, Inc., 1962.

Smoot, Robert C., et al., Chemistry, A Modern Course. Columbus: Charles Merrill Books, Inc., 1965.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter exists in small particles.

Title: The small particles of matter

ACTIVITY	QUESTIONS
Materials: sugar cube, mortar and pestle, filter paper, funnel, beaker, water	
Have students examine a cube of sugar.	Of what does this sugar cube seem to be composed?
Grind the sugar cube in the mortar.	What do we have now?
Place the powder on a piece of filter paper.	Why doesn't the powder go through the filter paper? How can we make the particles small enough to go through?
Stir into water and filter.	How can you tell that the particles of sugar passed through the filter?
Have students taste filtrate.	What is the difference between the particle size of the powdered sugar and the sugar in solution? How do you know? What size particle of sugar do you think we now have in the water? What evidence do you have that the invisible particles of sugar exist? What can we call these invisible particles of sugar?

Summary Statement: Matter is composed of small particles called molecules.

Concept Term: molecule

References:

Thurber and Durkee, Exploring Science. Rockleigh: Allyn and Bacon, 1964.

Jacobson, Willard J., et al., Probing Into Science. New York: American Book Company, 1965.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter exists in small particles.

Title: Molecules of gases

ACTIVITY	QUESTIONS
Materials needed: a penny balloon, balance Blow up the balloon and place on a balance and balance the system. Tie the end of the balloon so no air can escape.	What is inside the balloon? What is air a form of? Of what is air composed? Why can't you normally see air? How can I tell that air is in the balloon?
Set aside balloon for one day. Now set the balloon on the balance and note that it will not balance.	Why doesn't the balloon weigh the same? What did the balloon lose? Why did the air escape through the balloon? What evidence do you have to support this? What are these small particles called? What are the smallest particles which make up these molecules?
Research: Molecular structure, to the point only that molecules are composed of atoms.	

Summary Statement: Matter is composed of small particles called molecules which are composed of atoms.

Concept Terms: molecule, atom

References:

Jacobson, Williard J., et al., Challenges in Science. New York: American Book Company, 1961.

Pimental, George C., et al., Chemistry, An Experimental Science. San Francisco: W.H. Freeman and Company, 1963.

Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

23.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter exists in small particles.

Title: Construction of a molecule

ACTIVITY	QUESTIONS
Have students construct models of molecules based on their research. Allow for originality as to type of molecule and the material they use.	What is needed to make molecules? How might we construct a model of a molecule? What do all of your molecules contain?
Compare models of different molecules.	How is this model different from this one? How are these models alike?

Summary Statement: Molecules, which are small particles of matter, are made up of still smaller particles called atoms.

Concept Term: Atoms

References:

Jaworski, I.D. and Joseph, A., Atomic Energy. New York: Harcourt, Brace and World, 1961.

Freeman, Ira, All About the Atom. New York: Random House, 1961.

Brandwein, Paul F., et al., Concepts in Science-6. New York: Harcourt, Brace and World, 1966.

Jacobson, Willard J., Investigations in Science. New York: American Book Company, 1965.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter exists in small particles.

Title: Construction of an Atom

ACTIVITY	QUESTIONS
	Of what are molecules composed? What are the main parts of the atom? How might we make a model of an atom?
Have students construct models of atoms based on research. Allow for originality as to type of atom and the material they use.	What are the parts that all of your atoms contain? Where are the electrons located? Where are the neutrons located? Where are the protons located?
Compare students' models.	What element does your model represent? How are your models different? How are your models alike?

Summary Statement: Atoms are made up of small particles called electrons, protons and neutrons.

Concept Terms: proton, neutron, electron

References:

Brandwein, Paul F., et al., Concepts in Science-6. New York: Harcourt, Brace and World, 1966.

Mallinson, George G., Science 6. New York: Silver Burdett Company, 1965.

Jacobson, Willard J., Investigations in Science. New York: American Book Company, 1965.

Blough, Glenn O., et al., Elementary School Science and How To Teach It. New York: Holt, Rinehart and Winston, 1958.

Filmstrip, Atoms and Molecules. A427-22, S.V.E., Inc., Chicago, Illinois.

Filmstrip, The Atom. McGraw-Hill Filmstrips, New York, N.Y.

Filmstrip, The Structure of Atoms. McGraw-Hill Filmstrips, New York, N.Y.

Filmstrip, The Atom. Time-Life Series, New York, N.Y.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter exists in small particles.

Title: Construction of an Atom

ACTIVITY	QUESTIONS
	Of what are molecules composed? What are the main parts of the atom? How might we make a model of an atom?
Have students construct models of atoms based on research. Allow for originality as to type of atom and the material they use.	What are the parts that all of your atoms contain? Where are the electrons located? Where are the neutrons located? Where are the protons located?
Compare students' models.	What element does your model represent? How are your models different? How are your models alike?

Summary Statement: Atoms are made up of small particles called electrons, protons and neutrons.

Concept Terms: proton, neutron, electron

References:

Brandwein, Paul F., et al., Concepts in Science-6. New York: Harcourt, Brace and World, 1966.

Mallinson, George G., Science 6. New York: Silver Burdett Company, 1965.

Jacobson, Willard J., Investigations in Science. New York: American Book Company, 1965.

Blough, Glenn O., et al., Elementary School Science and How To Teach It. New York: Holt, Rinehart and Winston, 1958.

Filmstrip, Atoms and Molecules. A427-22, S.V.E., Inc., Chicago, Illinois.

Filmstrip, The Atom. McGraw-Hill Filmstrips, New York, N.Y.

Filmstrip, The Structure of Atoms. McGraw-Hill Filmstrips, New York, N.Y.

Filmstrip, The Atom. Time-Life Series, New York, N.Y.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter consists of elements and compounds.

Title: The grouping of elements

ACTIVITY	QUESTIONS
Materials: As many different samples of elements as can safely be made available.	How many things do you know of that are grouped or classified? Why do we group or classify things?
Have students observe the small samples of elements, record their observations, and then group the elements in any way they choose.	How did you group the elements? Why did you group them in this way?
Have different students report on how they grouped the elements. (Note to teacher: Try to get many different methods of groupings.)	How many different ways did we group these elements? Why are there so many different ways?
Give each group of students another element. Have them see if the element will fit into their grouping.	How successful were you in fitting the element into your group? Why?
Have two groups of students unite their groupings into one large group.	To what extent were you able to combine the two small groups into one large group? How might the grouping of these elements be helpful to you? How might a grouping of elements be helpful to scientists?

Summary Statement: The grouping of elements is accomplished by patterns or regularities of these elements.

References:

Smoot, Robert C., et al., Chemistry, A Modern Course. Columbus: Charles Merrill Books, Inc., 1965.

Choppin, Gregory and Jaffe, Bernard, Chemistry: Science of Matter, Energy, and Change. Morristown: Silver Burdett Company, 1965.

Brandwein, Paul F., et al., Concepts in Science - 6. New York: Harcourt, Brace and World, 1966.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter consists of elements and compounds.

Title: The periodic table

ACTIVITY	QUESTIONS
Give students a copy of the list included here of some of the elements, their properties, and numbers of atomic particles in each.	
Have students construct a table of these elements by whatever method they feel will classify the elements into a logical sequence. Have them assign a number to each element.	
Discuss the various ways in which students have listed the elements.	Why did you list them in this manner?
Have students observe the periodic table (expanded form) wall or individual type.	How is your table of elements different from this table of elements? How is it similar?
Have students regroup their elements according to properties and atomic structure. Again have students observe a periodic table and compare theirs with it.	How do you think this table is helpful to the scientist?
Have students observe an element which has not been included on the list (such as calcium) and list the probable properties of that element.	Why were you able to suggest the properties of this element?
Have students observe two elements on the chart which are next to each other, such as sodium and magnesium.	What differences do you observe between these elements? What might be some of the factors which cause elements to have different properties?
Discussion should include numbers and arrangement of outer electrons.	

Summary Statement: Elements may be grouped according to their physical and chemical properties.

Concept Term: periodic table

References: Brandwein, Paul F., et al., Concepts in Science - 6. New York: Harcourt, Brace and World, 1966.

Greenstone, Arthur W., Sutman, Frank X., and Hollingworth, Leland C., Concepts in Chemistry. New York: Harcourt, Brace and World, 1966.

Garrett, Alfred B., Richardson, John S., and Kiefer, Arthur S., Chemistry. Chicago: Ginn and Company, 1961.

	ELEMENT	PROPERTIES	E	P	N
1.	Phosphorous	Non-metal; combines with oxygen to form many different compounds; solid	15	15	16
2.	Neon	Non-metal; inert gas	10	10	10
3.	Silicon	Non-metal; relatively inert; solid	14	14	14
4.	Sodium	Metal; reacts with water; solid	11	11	12
5.	Hydrogen	Non-metal, active; very light gas	1	1	1
6.	Aluminum	Metal; combines with oxygen easily	13	13	14
7.	Argon	Non-metal; inert gas	18	18	22
8.	Nitrogen	Non-metal; combines with oxygen to form many different compounds; gas	7	7	7
9.	Helium	Non-metal; inert gas	2	2	2
10.	Beryllium	Very light metal; tarnishes in air; solid	4	4	5
11.	Carbon	Non-metal; relatively inert; solid	6	6	6
12.	Sulfur	Non-metal; reacts with metals; solid	16	16	16
13.	Magnesium	Very light metal; tarnishes in air; solid	12	12	12
14.	Flourine	Non-metal; very active; reacts violently with water; gas	9	9	10
15.	Lithium	Metal; very reactive with water; solid	3	3	4
16.	Boron	Non-metal; combines with oxygen easily; solid	5	5	6
17.	Oxygen	Non-metal; combines with metals readily; gas	8	8	8
18.	Chlorine	Non-metal; reacts with water; gas	17	17	18

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter consists of elements and compounds.

Title: A compound is made

ACTIVITY	QUESTIONS
Materials: powdered iron, powdered sulphur, magnets	What is iron? sulphur? What are the properties of the iron powder? What are the properties of the sulphur?
Have students weigh and mix together one gram each of iron and sulphur.	Do we still have iron and sulphur? How could we separate the iron from the sulphur?
Students should use magnet (with sheet of paper between) to separate iron from sulphur.	How might we get the iron and sulphur to combine to form a new substance?
Heat iron and sulphur mixture in an expendable pyrex test tube until reaction occurs.	What do we have now? How is it different from iron or sulphur?
Try separating iron with magnet.	What is the new substance called?
Use references.	

Summary Statement: Elements combine to form compounds.

Concept Term: compound

References:

Davis, Ira C., et al., Science 1, Observation and Experiment. New York: Holt, Rinehart and Winston, 1965.

Davis, Ira C., et al., Science 2, Observation and Discovery. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter consists of elements and compounds.

Title: The decomposition of sugar

ACTIVITY	QUESTIONS
Materials: sugar, crucible, heating source, electrolysis apparatus, battery, wooden splints, sulfuric acid	
Write on the board the formula for sugar.	What are the elements in this compound? What are their properties?
Students may use their charts from a previous activity.	What are some of the properties of sugar? How might we decompose sugar into its elements?
Heat the sugar in a crucible covered with a watch glass. Have students observe the results.	What remains in the crucible? How do you know? What collected on the watch glass? What is water? What elements are contained in water? How might we decompose water into its elements?
Research may be needed here on electrolysis.	
Set up apparatus as shown on page 3, Volume III of Curriculum Guide.	What was collected in the test tubes? What gases are they? How might we find out?
Test each gas with a lighted splint. First test oxygen gas.	What happened to the glowing splint? What gas is this?
Next test the hydrogen gas with a burning splint.	What happened to the burning splint? What gas might this be? In all cases, what was needed to separate the elements from the compound? (energy) What might you assume holds elements of compounds together?
Refer students to books and periodic chart. **Optional Research:** Chemical bonding	

Summary Statement: Compounds are composed of two of more elements chemically united.

Concept Term: element, compound

References:

Brandwein, Paul F., et al., Concepts in Science - 6. New York: Harcourt, Brace and World, 1966.

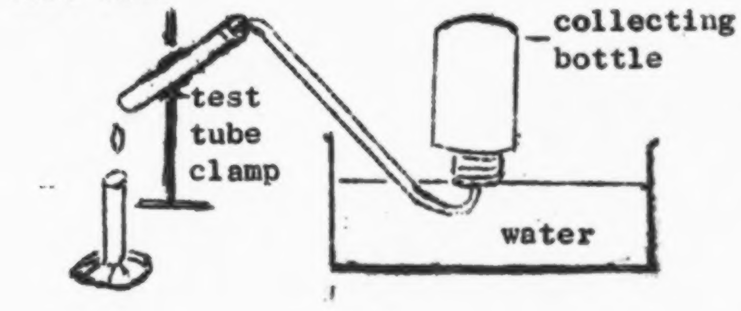
Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: Matter consists of elements and compounds.

Title: The decomposition of mercuric oxide

ACTIVITY	QUESTIONS
Materials needed: mercuric oxide water, ring stand, test tubes, heat source, collecting bottles, wooden splints, glass tubing	
List some compounds and their symbols on the board, including mercuric oxide.	What difference is there between the formulas of the compounds and the elements we have observed? How are the formulas for these compounds alike?
Have students observe a sample of mercuric oxide.	What two elements does this compound contain? What are their properties?
List the properties of mercury and oxygen on the board.	How do you know that these elements are in this compound? How might we find out for sure?
Heat the mercuric oxide in a test tube and collect the gas being given off by displacement of water.	



Observe the cool part of the test tube, just above the red mercuric oxide.	What do you observe collected on the test tube? How do you know? What gas do you think was given off? How might we find out?
Test the gas with a glowing wooden splint.	What happened to the glowing splint? Why is this a test for oxygen gas? How do the properties of these elements differ when they are locked in the compound? What was needed to separate the elements from the compound? Why was so much heat energy needed?

Summary Statement: Compounds are composed of two or more elements chemically combined.

Concept Term: element, compound

Auxiliary Word: decomposition

Reference: Marean, John H. and Ledbetter, Elaine W., *Physical Science, A Laboratory Approach*. Reading: Addison-Wesley Publishing Company, 1968.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: In a reaction the totality of matter remains constant.

Title: Matter retained

ACTIVITY	QUESTIONS
Materials: mercuric nitrate, potassium iodide, mortar and pestle	
Have students observe the two compounds	What are the properties of these compounds?
Have students weigh mortar and pestle and equal amounts of mercuric nitrate and potassium iodide. Grind the two compounds together until a change occurs and reweigh.	What change did you observe? What difference occurred in the weight?

Summary Statement: In ordinary reactions there is neither a gain nor a loss of matter.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: In a reaction the totality of matter remains constant.

Title: Zinc displaces copper

ACTIVITY	QUESTIONS
Materials: copper sulfate, zinc strip, water, small beaker, balance	
Have students dissolve a measured amount of copper sulfate in a beaker of water. Place a zinc strip into this solution. Weigh the whole system, cover and set aside for a day.	What are the properties of the solution? What are the properties of zinc?
The next day have students observe the solution and the zinc in the beaker.	What has happened to the solution? What has happened to the zinc? Where do you think the new substance came from?
Reweigh the beaker and contents	What is the weight now? What difference occurred in the weights?

Summary Statement: The mass of a confined system does not change when a chemical reaction occurs.

Reference: Marean, John H., and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: In a reaction the totality of matter remains constant.

Title: No loss

ACTIVITY	QUESTIONS
Materials: two small vials (one with cap and thin rubber washer), $\frac{1}{2}$ Alka-Seltzer tablet, balance	
Have students add equal amounts of water to each vial and split the $\frac{1}{2}$ Alka-Seltzer tablet into two equal parts. Place open vial and $\frac{1}{4}$ tablet on balance, weigh, and record. Drop tablet into vial and leave open.	What is happening to the Alka-Seltzer tablet? What is being given off? What do you think will be the weight of the vial now?
Reweigh and record.	Why is there an apparent loss of weight in this reaction? Was matter destroyed in this reaction? How could we find out?
Place second vial (washer in place), cap, and $\frac{1}{4}$ tablet in balance, weigh, and record. Drop tablet into vial and seal quickly with cap.	What is happening to this tablet? What is being given off? How is this reaction different from the first? What did we do differently? What do you think will be the weight of this vial?
Reweigh and record weight.	How do you explain the apparent difference in weight loss between the first reaction and the second?

Summary Statement: In a reaction, there may be an apparent loss of weight due to escaping gases.

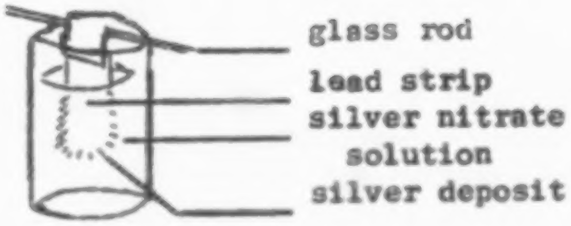
Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: In a reaction the totality of matter remains constant.

Title: Making a silver tree

ACTIVITY	QUESTIONS
OPTIONAL	
Have available the following materials: lead strips about 8" x 2", silver nitrate solution (25 gms/liter of water or 2.0 gms/80 ml of water), solid glass rods, 100 ml beakers or other glass containers, triple beam or platform balance.	
Instruct students to fill their beakers 3/4 full of silver nitrate solution.	
Note to teacher: Solution should be prepared in advance.	
Using a triple beam or platform balance, each student should carefully weigh the beaker of solution, metal strip and a glass rod and add them together. The results should then be recorded in a notebook.	
After weighing instruct students to examine the lead strip and the solution of silver nitrate.	What color is the strip of metal? What color is the solution? What do you suppose would happen if the metal strip were placed in the solution of silver nitrate? How might we find out?
Instruct the students to set up materials as shown in illustration on the following page.	

Illustration:



Set aside and observe until end of period or continue next day.

Note to teacher: It is advisable to have students cover their containers with a piece of tinfoil or saran wrap to prevent any loss of water by evaporation.

What has happened to the strip of metal?
Where did the silver substance come from?
How do you know?
How could you find out?
(Students could set up similar experiment substituting water for silver nitrate solution.)
How does the amount of matter which you had at the beginning of this experiment compare with the amount of matter you have now?
How could you find out?
(Students will probably suggest re-weighing all the materials.)
Why did the weight remain the same even though a "new" substance appeared on the strip of metal?

Summary Statement: In any chemical reaction the total amount of matter remains the same.

Concept Term: displacement

References: Nebergall, William H. and Schmidt, Frederic C., *General Chemistry*. Boston: D.C. Heath and Company, 1963.

Greenstone, Arthur W., Sutman, Frank X. and Hollingworth, Leland G., *Concepts in Chemistry*. New York: Harcourt, Brace and World, 1966.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: With extraordinary (uncommon) methods matter can be destroyed to release energy.

Title: Making a self-portrait of a radioactive mineral

ACTIVITY	QUESTIONS
Materials: Polaroid film pack, radioactive mineral, non-radioactive stone. Place the mineral and the stone on one of the films from the pack. Place in a drawer and allow to stand for two weeks. After this period of time, develop the Polaroid film as per instructions on film pack.	
Have students observe the developed film.	What has happened to the film? Why do you think this has happened? How are the effects of the stone different from those of the mineral? Why do you think we left the film exposed for as long as we did?

Summary Statement: Some matter gives off particles that affect photographic film.

Concept Term: radioactive

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: With extraordinary (uncommon) methods matter can be destroyed to release energy.

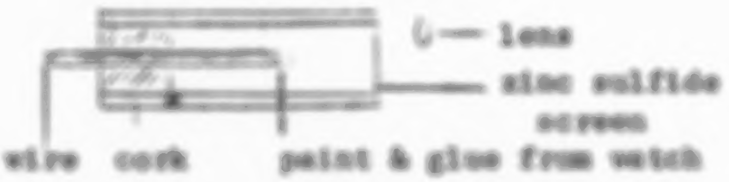
Title: Other materials which are radioactive

ACTIVITY	QUESTIONS
Materials: Polaroid film pack, orange-colored ceramics or orange glaze which contains uranium compounds, luminous clock or watch dial Have students place the above material on the Polaroid film. (The orange-colored "Fiesta Ware" dishes contain pure uranium oxide and will work very well.) After a period of ten days develop film as per instructions on Polaroid pack.	What objects had their "pictures" taken? Why do you think this happened? How can you explain the shadows on the film?

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: With extraordinary (uncommon) methods matter can be destroyed to release energy.

Title: Detection of Alpha particles

ACTIVITY	QUESTIONS
Materials: zinc sulfide, cellulose tape, 4"-5" long cardboard tube, piece of wire, cork, small convex lens or eye piece of microscope, old luminous watch dial	
Dust strips of the tape with zinc sulfide and fasten to the end of the tube (zinc sulfide side inside tube). Scrape a small amount of the paint from the luminous watch dial onto a small drop of glue on one end of the piece of wire. Push the end of the wire through the cork.	
Have students become adapted to a dark room and observe the screen through the lens. Move the wire in and out until they begin to see flashes on the screen.	What do you observe? What might be the cause for this? Of what is light a form? What is the source of the light? What must occur in an atom to release the energy? What happens to the atom?
 lens zinc sulfide screen wire cork paint & glue from watch	
Optional: Compare the strength of several different sources.	

Summary Statement: The atom is made up of smaller particles, some of which can be converted to energy.

Concept Term: Alpha

References:

Sisters Mary Hermias and Mary Joecile, *Radioactivity: Fundamentals and Experiments*. 1963.

Hone, Elizabeth B., et al., *Teaching Elementary Science: A Sourcebook for Elementary Science*. New York: Harcourt, Brace and World, 1962.

Conceptual Scheme: MATTER MAY BE TRANSFORMED; UNDER ORDINARY (CLASSROOM-LABORATORY) CONDITIONS IT IS NOT CREATED OR DESTROYED.

Concept: With extraordinary (uncommon) methods matter can be destroyed to release energy.

Title: Nuclear Reactors

ACTIVITY	QUESTIONS
Refer students to various books dealing with nuclear reactors, how they work, and how they are constructed.	What is the fuel for a nuclear reactor? What is a chain reaction?
Place a number of mouse traps in an aquarium. Set the traps and place ping pong balls on the triggers of the traps. Throw in one ping pong ball.	What might this ping pong ball represent? What happened to the mouse traps? How do you explain what occurred? What did this represent? What is the difference between a chain reaction in a reactor and a chain reaction in an atomic bomb?
Have students construct a model nuclear reactor. Allow for originality.	How did you construct your reactor? What does each part represent? What is the function of each part? What does a nuclear reactor produce? How does it produce these various forms of energy? What can nuclear reactions be used for?
Optional Activity: Peaceful uses of nuclear energy.	

Summary Statement: The destruction of matter to produce energy can be controlled and put to many uses.

Concept Term: nuclear energy

Reference: Brandwein, Paul F., et al., Concepts in Science - 6, New York: Harcourt, Brace and World, 1966.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED

Concept: Energy must be used to set an object in motion.

Title: An Energy Conversion System

ACTIVITY	QUESTIONS
Materials: a wind-up toy car	What do I have to do to make this car move? What do I have to have in order to wind up this toy?
Wind up toy and allow it to move.	What causes the car to move? What did I give to the spring?
Wind up toy half way and allow it to move.	How long did the car move?
Wind up toy all the way and allow it to move.	Why did the car run longer?
Have toy car push a small object.	Why did the small object move? What did the car give to the object? What is needed to move any object?

Summary Statement: Energy is required to set objects in motion.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy must be used to set an object in motion.

Title: Work is dependent upon force and motion

ACTIVITY	QUESTIONS
Materials: 1 kilogram mass, spring balance, meter stick, small box of sand	
Hold weight a meter high above box of sand.	What will happen if I release this weight? Why?
Let weight drop.	What happened to the sand? Why? How much work was done?
Refer students to various references.	How much work is required to raise this weight one meter high?
Attach spring balance to the weight and have students raise weight slowly and steadily a height of one meter.	What was the reading on the balance as you raised it? What was the reading when the weight was held stationary? What would be the reading on the balance as the weight is lowered?
Have students lower weight slowly and steadily and record reading on balance.	How much work did you do in raising the weight? When the weight was stationary? When you lowered it?
Again raise weight.	If the weight were dropped how much work could it do?
Now move the weight horizontally one meter.	How much work will the weight do if it is dropped from there? What is the difference between the two positions? How much work did you do in moving the weight horizontally one meter? How do we know that this work is not recoverable through the action of gravity? What important factors contribute to work done?

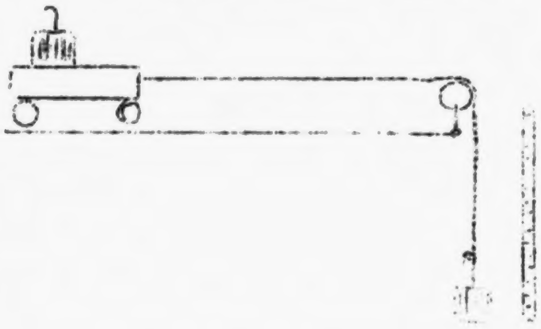
Summary Statement: The motion in the direction of the force is a contributing factor to work done.

2

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED

Concept: Energy must be used to set an object in motion

Title: Work is done when an object is moved

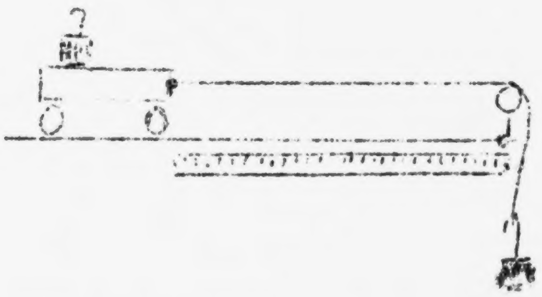
ACTIVITY	QUESTIONS
Materials: Hall's Carriage, set of weights, meter stick, pulley, string Set up apparatus as follows: 	
Weigh the Hall's Carriage and place a 50 gm weight inside it.	How much force would be needed to move this carriage?
Add the weights to the end of the string a little at a time until the cart just starts to move.	How much weight was required to cause the cart to move? Why did it take more weight to move the cart than we predicted?
Measure the distance the weight falls.	How much work was done when the weight fell?
Now pull the carriage with a spring balance slowly and steadily a distance equal to the distance the weight fell.	How much work was done in moving the carriage? Why is there a difference?

Summary Statement: Factors which have to be overcome in doing work are friction and inertia.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy must be used to set an object in motion.

Title: Motion is directly proportional to force

ACTIVITY	QUESTIONS
Materials: Hall's Carriage, set of weights, meter stick, pulley, stop-watch, string Set up the apparatus as follows: 	
Place a weight in Hall's Carriage, fasten the string to the cart and have the other end go over a fixed pulley. Fasten to the end of this string another weight. Measure the distance cart will travel and the distance the weight travels. Allow the weight to drop the measured distance and measure the amount of time needed for the carriage to travel the measured distance.	How much work was done by the falling weight? How fast was the cart moving? Why did the cart start slowly then gain in speed? What would happen if we doubled the weight on the string?
Place another weight on the end of the string such that the weight is doubled. Repeat as above.	What happened to the speed of the cart? Why do you think this occurred? How much work was done?

Summary Statement: As the amount of energy used is increased, the amount of motion is increased.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED

Concept: Energy must be used to set an object in motion.

Title: Free fall

ACTIVITY	QUESTIONS
	What is a sky diver? How fast does a sky diver fall in his first 100 feet from the plane? How fast will he be falling when he is near the ground? How can we find out?
Select an object to represent the diver and drop it from the highest possible point in the classroom. (tall boy on a desk) Drop the same object from desk height.	Which one struck the floor in the shortest time? Which would fall faster, a heavy or light object? How can we find out?
Drop a book and an eraser from the same height.	Which one struck the floor first? Why?
Try a piece of aluminum foil and a crumpled piece of foil the same size dropped as before.	Which one struck the floor first? Why? How can you time this fall?
Material needed: trough or flat board 4 to 6 feet long, ping-pong ball, long sweep stop watch or metronome or pendulum.	
The fall of heavy and light objects, or free-fall from the desk top may be difficult to measure. Try a gently sloped board about two books high at one end and a ping-pong ball.	When does the ball seem to be moving fastest? What is causing the ball to roll down the slope? How would increasing or decreasing the angle of the slope affect the speed of the ball?
Have each group set up a time interval (as small as possible) and record the time and distance covered by the ball as it rolls down the slope.	

50.

During what time interval does the ball cover the greatest distance?

What pulls constantly on you now (even at rest)? (gravity)
What is gravity a form of?

Summary Statement: Freely falling bodies increase their velocity with each period of time (acceleration).

Concept Term: acceleration

References:

Dull, Charles E., et al., Modern Physics. New York: Holt, Rinehart and Winston, 1964.

Fischler, Abraham S., et al., Science, A Modern Approach - Book 6. New York: Holt, Rinehart and Winston, 1966.

Lehrman and Swartz, Foundations of Physics. New York: Holt, Rinehart and Winston, 1965.

Weisbruch, Fred T., et al., A Laboratory Text for Physical Science. Kirkwood: 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy must be used to set an object in motion.

Title: Friction

ACTIVITY	QUESTIONS
Materials needed: bricks or wooden blocks, spring balances, string, sandpaper, wooden rods or rollers, pans for water	
Instruct students to place bricks or blocks on a smooth surface, such as a board. Note: Wrap brick in felt to avoid marring desk surface if boards cannot be used.	What must you apply to the brick to make it move across the surface? (force) What is needed to produce this force? Where does this energy come from? Why is force needed to move an object across a surface? (to overcome resistance) What do we call this resistance? (friction)
Have students attach spring balance to their brick with a piece of string and pull it at a constant rate across the surface.	
Note: Caution students to keep the string as nearly horizontal with the surface as possible.	Why should string be kept horizontal?
Have students repeat above activity substituting a piece of sandpaper in place of the desk surface.	How much force was needed to pull the brick across the desk (table) surface? How much force was needed to pull the brick across the sandpaper? How do you account for the difference? How might the amount of force needed to pull the brick across the desk be lessened? (Students may suggest using rollers or placing a film of water between the surfaces.)

Instruct students to measure force needed to move brick or block using both rollers and a surface of water. **Note:** If a wooden block is used it may be floated in a shallow pan of water and pulled across the pan.	How does the amount of force required to move the block using rollers or a film of water, compare with that required to move it across the desk surface? Why?
Instruct students to again attach spring balance to brick or blocks and pull across desk surface with brick placed on its narrow rather than flat side. Repeat, this time placing brick again on its broad side and adding weights on top of the brick.	How did placing the brick on its narrow side affect the amount of force needed to pull it? Why? How did adding weights to the brick affect the amount of force needed to pull it? Why? What do you think are the two most important factors determining the amount of friction between any two surfaces? How is friction useful? How is friction harmful?

Summary Statement:	Friction is a force which resists motion. It depends on the force (weight) between the two surfaces and the nature (roughness) of the surfaces.
Concept Term:	friction
Auxiliary Words:	force, resistance
References:	Alexander, Joseph, et al., A Sourcebook for the Physical Sciences. New York: Harcourt, Brace and World, 1961. Pella, Milton O. and Wood, Aubrey, Physical Science for Progress. Englewood Cliffs: Prentice-Hall, Inc., 1964.

OPTIONAL

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy must be used to set an object in motion.

Title: Coefficient of friction

ACTIVITY	QUESTIONS
This activity is to be an expansion of the previous activity on friction.	
Materials needed: bricks or wooden blocks, spring balances, weights, string	
Begin with review of previous lesson on friction.	What determines the amount of force needed to overcome friction between any two surfaces? (weight of object; roughness of surfaces)
Instruct students to weigh brick or block and record results. Instruct students to again attach spring balance to their bricks or blocks of wood and pull across smooth boards. They should record force needed to pull block at a constant speed. Repeat, this time placing 500 grams of weight on top of the brick (block) before pulling it across the surface.	How much force was needed to move the brick the first time? How much force was needed the second time? Why was there a difference? How did the amount of force required to overcome the friction (move the object) in each case compare with the weight of the object? How might you find out? (Divide the force by the weight of the object.) $\frac{F}{W}$ What kind of answer do you obtain? (a fraction or a decimal) What does this answer really show? What do you suppose this comparison is called? (Students probably will not know.) Where might you find out?

If students do not suggest it, have them do research in books available. They should come up with answer -- coefficient of friction.

Additional Investigation: Have students show as many ways as possible of reducing the amount of friction between two surfaces.

What does coefficient mean? (constant or comparison)

What happens to the energy?

Summary Statement: The coefficient of friction is a constant which shows the amount of force needed to overcome friction between two surfaces.

Concept Term: coefficient

Auxiliary Word: friction

References:

Brandwein, Paul F., et al., Exploring the Sciences. New York: Harcourt, Brace and World, 1964.

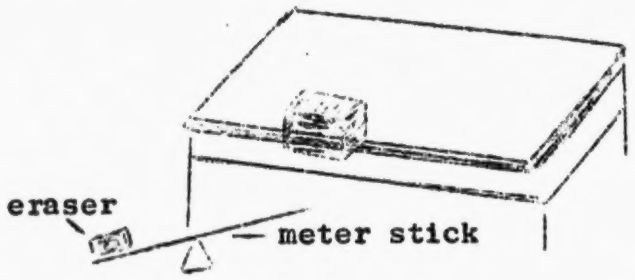
Dull, Charles, et al., Modern Physics. New York: Holt, Rinehart and Winston, 1963.

Pella, Milton O. and Wood, Aubrey G., Physical Science for Progress. Englewood Cliffs: Prentice-Hall, Inc., 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: There are different forms of energy.

Title: We learn about potential and kinetic energy

ACTIVITY	QUESTIONS
Have pictures of a lake, a dam, a rock on top of a hill or any others which show potential and kinetic energy. Place an object, such as a wooden block, on the edge of a table and set up the apparatus as shown:  	
Refer to pictures illustrating potential energy.	What work can these objects do? What must happen to them in order for them to do work?
Refer to block on table.	What work can this block do? What must I do in order for it to do work?
Push block off the table so it hits the raised end of the meter stick.	What happened to the eraser? How do you know work was done? What had the energy to do the work? Where did the block get its energy? (falling)
	What two different types of energy does this block possess? How might we find out?
Research: potential energy kinetic energy	

Summary Statement: Potential energy and kinetic energy can each be changed into the other.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: There are different forms of energy.

Title: Sound vibrations

ACTIVITY	QUESTIONS
Materials needed: pictures of various percussion musical instruments, such as, a drum, a xylophone, a triangle, a glockenspiel, and a flexible metal strip (hack saw blade)	
Have students shut their eyes and listen to sounds around them.	What sounds do you hear that are made by animals? What sounds do you hear that are made by people? What sounds do you hear that are made by large and small machines?
Have students make a list of the different sounds they heard in one minute.	How do you think sound reaches us? What is the difference between sound and waves? How might we find out?
Have students do research on sound and sound waves. Place pictures of the musical instruments before the class and refer to them as sound makers.	What do the instruments have in common? (They belong to the same class and each has a part that vibrates.) What force causes the sound makers to vibrate? (a push or a pull--energy)
Have students start a record in their data books whereby they will group sound makers according to source of sound, force which cause vibrations and the part that vibrates.	What part of a violin vibrates? What part of a trumpet vibrates? What part of a saxophone vibrates? What part of a drum vibrates? What part of a piano vibrates?
Place a rubber sheet over a small battery jar or similar container. Strike the tightly drawn rubber sheet with a little force. Increase the force a little at a time.	

	What change in sound is produced by a change in force? (a greater force increases loudness -- amplitude)
Place a flexible metal strip, such as a hacksaw blade in a vise. Snap the end of the metal strip gently and observe the movement of the metal strip.	What type of motion do you notice? (back and forth motion--vibration) What do you hear? (a sound) What causes this sound? (vibration) What was necessary to cause snap of the blade? (a push or pull--energy)
Snap the end of the metal strip with more force than before.	What do you hear? (a louder sound) How do the movements of the blade vary? (larger) How are the sounds different? (louder)

Summary Statement: Sounds are caused by vibrations--rapid back and forth motions.

Concept Term: vibration

Auxiliary Words: force, sound, waves, volume

References: Heimler, N., Principles of Science. Columbus: Charles Merrill Books, Inc., 1966.

Stone, G. K., and Stephenson, L.W., Science in Action. Englewood Cliffs: Prentice-Hall, Inc., 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: There are different forms of energy.

Title: **Magnets**

ACTIVITY	QUESTIONS
Materials needed: magnets, large sheets of paper, paper clips or other object which may be attracted by a magnet, and as many compasses as there are magnets in use.	
Place a paper clip on a desk.	What kind of energy does this paper clip possess? (potential)
Move the paper clip by means of a magnet.	What form of energy did the paper clip have while in motion? (kinetic) What was required to cause the change in the form of energy? (force) Where did the force come from? How do you know? How can we set up an experiment to show what caused the paper clip to move?
Note: The students may suggest the "classic" iron filings experiment. The teacher may use the iron filings experiment, the following experiment, or allow both to be done.	
Have the students place their magnet in the center of a large sheet of paper. They should trace the outline of the magnet and label the drawing as to north and south magnetic poles. Have the students place a compass at one end of the magnet. Place a mark at the end of the compass needle away from the magnet. Move the compass until the point of the needle closest to the magnet is touching the mark on the paper. Place another mark at the end of the compass needle, farthest away from the magnet.	

Continue this process until the other end of the magnet is reached. The result will be a series of dots representing one line of force of the magnet. Connect these dots. Repeat the process until you have a good graphic representation of the lines of force of a magnet.

Note: Research into the theories of magnetism should be culminated by a class discussion.

What have we diagrammed?
(lines of force of a magnet)
What causes this force?
How can we find out? (research)

Summary Statement: Magnets are a source of energy.

References:

Brandwein, Paul F., et al., Exploring the Sciences. New York: Harcourt, Brace and World, 1964.

Brandwein, Paul F., et al., The World of Matter and Energy. New York: Harcourt, Brace and World, 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: There are different forms of energy.

Title: Light energy behaves in different ways

ACTIVITY	QUESTIONS
This is designed to be a research activity on theories regarding the nature of light energy.	What is light? (energy) How do you know? (Students will probably not know the answer.) Where could you find out? (Students may suggest doing research by using books available.)
Suggest students consult as many sources as possible, (books, magazines, etc.) to learn about the nature of light and write down what they learn.	How do scientists explain the nature of light? (Students will probably suggest particle and/or wave theories.) What is a theory? Which theory do you find the more acceptable? Why?
Discussion should be allowed to develop as fully as the students can comprehend.	
Have students examine a light meter in different locations and with varying intensities of light.	What makes the needle on this meter move? When do you notice the greatest movement? Why?
Students may want to read about how a light meter works.	Which theory of light seems to be supported by the light meter? Why?

Summary Statement: The exact nature of light energy is not fully understood, but is best explained by the particle and wave theories.

Concept Term: light energy

Auxiliary Words: particle, wave, theory

References:

Brinkerhoff, Richard, et al., The Physical World. New York: Harcourt, Brace and World, 1958.

Jacobson, Willard J., et al., Investigations in Science. New York: American Book Company, 1965.

Pella, Milton O., and Wood, Aubrey G., Physical Science for Progress. Englewood Cliffs: Prentice-Hall, Inc., 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: There are different forms of energy.

Title: Sound as a form of energy

ACTIVITY	QUESTIONS
Materials needed: tuning forks	
Have students place finger tips on their throats. Have them make a sound.	What did you feel?
Start a tuning fork vibrating. Put it in a pan of water.	What do you see? What is causing this?
Set up two tuning forks having the same pitch. Start one vibrating.	What has happened to the second tuning fork? What caused this? Why? How do we hear a sound?

Summary Statement: Sound is a form of energy.

Concept Terms: sound energy, vibration, pitch

References:

Beauchamp, Wilbur L., et al., Science is Understanding. Chicago: Scott, Foresman and Company, 1964.

Lehrman and Swartz, Foundations of Physics. New York: Holt, Rinehart and Winston, 1965.

Schneider, Herman and Nina, Science for Today and Tomorrow. Boston: D. C. Heath and Company, 1965.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: There are different forms of energy.

Title: Chemical energy

ACTIVITY	QUESTIONS
Have available materials for constructing models of atoms or use previously built models.	
Review structure of atoms using the models as a guide.	What are the three principal kinds of particles found in the atom? Which particles in an atom may be transferred to other atoms? How is it possible for atoms to combine with each other? What is necessary for this combination to take place?
Have pupils construct a model of two or more atoms which have been combined. Then have them break this bond.	What have you done? What was required in order to break this bond? What was released when this bond was broken? Why? What kind of energy does a chemical bond contain? Why? Would the amount of energy necessary to break a chemical bond be more or less than the amount required to keep it intact?

Summary Statement: The nature of chemical energy is due to the existence of atomic bonds.

Auxiliary Word: chemical bond

References: Posin, Dan Q. and Shampo, Marc, Chemistry for the Space Age. Philadelphia: J.B. Lippincott and Company, 1964.

Brandwein, Paul F., et al., Exploring the Sciences. New York: Harcourt, Brace and World, 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: There are different forms of energy.

Title: Electricity: A form of energy

ACTIVITY	QUESTIONS
Materials needed: rubber rods, glass rods, silk cloth, wool or fur, and silk thread.	
Hold up a rubber rod.	What is the basic building block of this rubber rod? (atom) What are the parts of the atom? Where are these parts located? What charges do these particles have? How might we find out?
Refer students to books to find out charges on atoms. Have students suspend a small piece of paper by a silk thread. Hold the rubber rod (uncharged) near the piece of paper.	What happened?
Rub the rubber rod with a piece of woolen cloth. Hold it near the piece of paper.	What happened? What caused this? Where did the charge come from? How can we explain this? (Electrons flow to the rubber rod from the cloth.) What kind of charge was created on the rubber rod? (negative)
Pass out pieces of glass rod and silk cloth. Have the students suspend two pieces of paper approximately ½" to 3/4" apart. Give time to investigate with all of the equipment in front of them. Have them record their investigations and record their observations. Discuss the various investigations the students tried.	Why didn't each investigation result in the same reaction? What occurred in some cases? What evidence was there of an electron exchange?
Research: lightning	

Summary Statement: Electrical energy is a function of the motion of electrons.

References: Brandwein, Paul F., et al., *Exploring the Sciences*.
New York: Harcourt, Brace and World, 1964.

Davis, Ira C., et al., *Science 3, Discovery and Progress*.
New York: Holt, Rinehart and Winston, 1965.

Jacobson, Willard J., et al., *Adventures in Science*.
New York: American Book Company, 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: There are different forms of energy.

Title: Some machines produce many forms of energy

ACTIVITY	QUESTIONS
Have available a small hand-powered magneto generator. Be sure there is a light bulb in the socket.	
Note: This may be performed as a demonstration experiment if materials are limited.	
Have students examine the generator.	What is this device? (Students will probably not know, intended answer is machine.) What is a machine used for? What is needed for a machine to do work?
Turn or have student turn crank of generator rapidly, causing bulb to light.	What kind of energy was used to operate this machine? Where did this energy come from? (person operating the generator) Where did he get his energy? What kind of energy do we call this?
Repeat operation of generator.	How many kinds of energy can you observe when the generator is operated? What are they?
Note: Students may list them orally or write them on paper.	How do you know all these forms are present? (Light energy can be seen, sound energy heard, etc.) What forms of energy exist that we do not get from this machine?

Summary Statement: There are many forms of energy.

References:

Boylan, Paul J., Elements of Physics. Rockleigh: Allyn and Bacon, Inc., 1962.

Brandwein, Paul F., et al., Exploring the Sciences. New York: Harcourt, Brace and World, 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: There are different forms of energy.

Title: Radiant energy

ACTIVITY	QUESTIONS
Divide the class into two groups. Have group one report on how the sun's energy reaches the earth. They should construct experiments to show this. Have group two report on how the sun's energy may be used. Have them construct models (preferably working models) of solar (radiant) energy conversion devices. Note: The following subjects could be investigated: Group #1 1. Theories of travel 2. Visible and invisible radiant heat 3. "Physical" reactions (such as reflection) 4. Sources Group #2 1. Solar furnaces 2. Solar batteries 3. Solar cooking	What is the basic source of the Earth's energy? How does this energy reach us? How can this energy be used?

Summary Statement: Radiant energy (from the sun) is an important source of energy.

References:

Beauchamp, Wilbur L., et al., Science is Understanding. Chicago: Scott, Foresman and Company, 1964.

Brandwein, Paul F., et al., Exploring the Sciences. New York: Harcourt, Brace and World, 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy can be changed from one form to another.

Title: Light energy to chemical energy

ACTIVITY	QUESTIONS
This should be an individual or a group activity depending on materials available.	
Materials needed include: silver nitrate crystals, suitable amounts of chloride salt, such as sodium or barium chloride, glass containers, glass funnels, stirring rods.	
Begin with a discussion about sunlight as a form of energy.	What kinds of energy do you associate with sunlight? (Students will probably say heat and light.) What other name is often given to energy of sunlight? How do you think the energy of sunlight might affect some chemical substances? (Students will probably not know.) How might we find out?
Instruct students to dissolve a very few crystals of silver nitrate in a beaker or container of distilled water and stir thoroughly. Caution Be sure containers used are clean.	
Students should then add a few grains of sodium chloride to the solution until it becomes milky or cloudy. Filter part of this solution, then have students remove the filter paper and place it in an area exposed to considerable sunlight. This should be allowed to stand overnight and observed by the students the following day.	What has happened to the filter paper? Why?

Optional Activity:

Materials needed: blueprint paper.
Give each student a small (2" x 2" maximum) piece of blueprint paper. Pass out upside down and have them keep them out of the light (under a book or similar object). Have the students place an object (a key, coin, pencil) on the paper. Place the paper in sunlight and/or other light sources. The time element will require planning and testing by teacher.
Have students wash the paper thoroughly under running water. Dry with paper towel. Press until completely dry.

What happened to the paper?
What caused the change?
How much influence did the various intensities of light have on the change?
How would you explain this?

Summary Statement: Light energy may be changed to chemical energy.

Auxiliary Word: solution

References:

Garrett, Alfred B., Richardson, John S., and Kufer, Arthur S., Chemistry. New York: Ginn and Company, 1961.

Posin, Dan Q., Shampo, Marc, Chemistry for the Space Age. Philadelphia: J. P. Lippincott and Company, 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy can be changed from one form to another.

Title: Radiation and the radiometer

ACTIVITY	QUESTIONS
Obtain a radiometer. Have students examine the instrument and note how it is constructed.	Why do you think the blades are painted black on one side and silver on the other? (The black side absorbs more energy, becomes hotter and causes the air molecules to bounce off from it with more "kick" than from the polished side.)
Watch the blades when the radiometer is placed in the presence of light.	What happens to the blades of the radiometer after exposure to light?
The radiometer does not measure radiation, but it is a sensitive detector of radiant energy.	
Place the radiometer away from any very bright sources of light.	What do you observe when the radiometer is removed from a bright source of light?
When the blades are perfectly still, use a small flashlight and allow a beam of light to fall on the blades of the radiometer.	What happens when a beam of light is allowed to fall on the blades? What type of energy causes the blades to be set into motion? How do you think heat would affect a radiometer? How can you find out?
Use various sources of heat, such as a flashlight, candle, bunsen burner, etc., and compare the rates of spin, remembering to place each source the same distance from the instrument, assuring true comparison.	What do scientists generally call the type of energy which causes the radiometer blades to be set into motion? What type of transformation did you notice?

Research: There are many different types of radiation, both harmful and non-harmful. The problems of radiation are often in the news. Keep a notebook in which you record recent advances in our knowledge of radiation.

Summary Statement:	Radiant energy can be transformed into mechanical energy.
Concept Term:	radiation
Auxiliary Words:	absorb, molecule, transformation
References:	Boylan, Paul J., Elements of Physics. Rockleigh: Allyn and Bacon, Inc., 1962. Fischler, Abraham S., et al., Science, A Modern Approach. New York: Holt, Rinehart and Winston, 1966.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

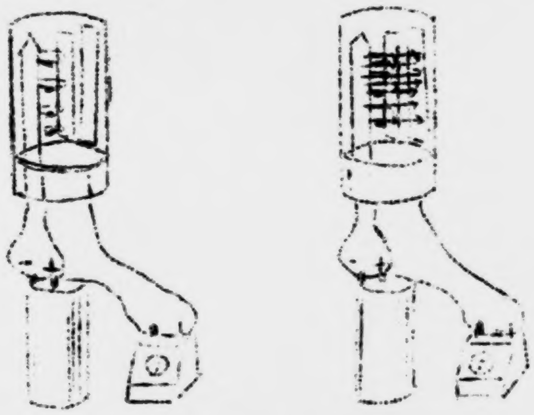
Concept: Energy can be changed from one form to another.

Title: Heat energy can produce electrical energy

ACTIVITY	QUESTIONS
Have available wires of two different metals (such as iron coat hanger wire and copper wire), bunsen burner, or other heat sources, galvanometers. Have pupils work in pairs or small groups.	What will happen to the wires if they are placed in your bunsen burner flame? Why? What kind of energy would they then contain? What will happen if the ends of the two wires were fastened together before they were heated? (Both wires would get hot.)
Instruct pupils to fasten the ends of the two different cold wires together. Before heating have pupils attach other end of iron wire to one post of a galvanometer and the end of the copper wire to the other post.	
Note: Teacher may wish to give brief explanation of how the galvanometer works, if it has not been done previously.	
Instruct pupils to gently heat ends of two wires where they have been connected and observe needle of the galvanometer.	What happens to the needle as the wires are heated? Why? Where did the electricity come from? How could you make certain? (Stop heating and needle will fall.) What do we call the union of two different metals which produces electricity when heated? (thermocouple) (Students may not know the answer.) Where could you find out?

Optional Activity: This activity is suggested for a more advanced group. Have students or groups of students connect radio tubes (triodes) to one or more 1½ volt dry cells and galvanometers or ammeters as shown in the diagram below.

Illustration:



THE TRIODE SETUP

What happened to the tube after it was attached to the dry cell(s)? (Students will probably observe the tube giving off light and heat.)
How was the needle of the galvanometer affected?
Why?
Why couldn't electricity be detected when the tube was first connected?

Summary Statement:	Heat may serve as a source of electricity.
Concept Term:	thermocouple
Auxiliary Word:	galvanometer
References:	Lehrman and Swartz, Foundations of Physics. New York: Holt, Rinehart and Winston, 1965. Stone, G. K., Science Projects You Can Do. Englewood Cliffs: Prentice-Hall, Inc., 1966.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy can be changed from one form to another.

Title: Heat energy can be changed to mechanical energy

ACTIVITY	QUESTIONS
Have available pinwheels (made from aluminum foil pie plates), wooden dowels or rods, ringstands to support the rods and electric light bulbs to serve as a heat source.	
Have students turn on electric light bulbs and observe.	What kind of energy makes a light bulb work? How many kinds of energy does a light bulb produce? How do you know this?
Instruct students to place wooden rods in an upright position and support them with their ringstands. Students should then attach foil pinwheels to tops of wooden rods by inserting a pin or thumbtack through the hole in center of pinwheel and pressing into top of rod.	
Note: Pinwheels should be free to turn or pivot about the pin.	
Have students spin pinwheels with their fingers.	What kind of energy did you use to make the pinwheel move? Where did this energy come from? How else could you cause the pinwheel to move? (Students will probably suggest blowing against it.) What do you think would happen if we put a light bulb beneath the pinwheel? How could we be certain?
Allow students to place light bulbs beneath pinwheels and observe.	What did the pinwheel do after the light bulb was placed beneath it? Why?

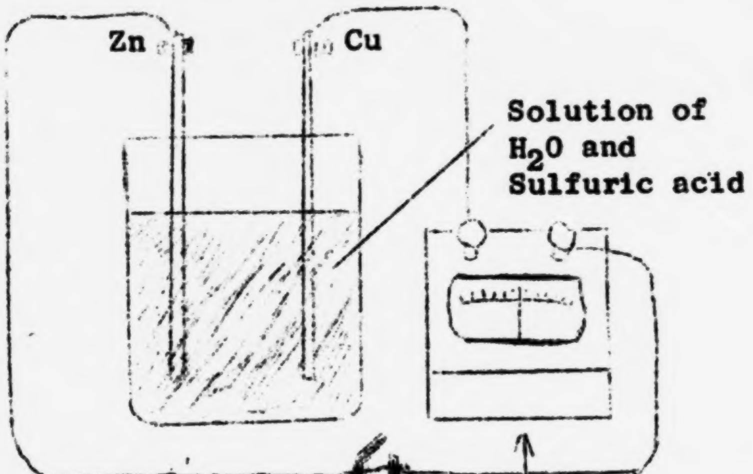
Summary Statement: Heat energy can be changed to mechanical energy.

Reference: Brandwein, Paul F., et al., The World of Matter and Energy. New York: Harcourt, Brace and World, 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy can be changed from one form to another.

Title: Transforming chemical energy into electrical energy

ACTIVITY	QUESTIONS
Materials needed: copper strips, zinc strips, solution of dilute sulfuric acid, bell wire, galvanometer, beakers or other glass containers. Students can make a simple cell by placing a copper strip and a zinc strip in a solution of dilute sulfuric acid. Connect the zinc and copper strips to a switch and a volt meter by using bell wire: Illustration:  Zn Cu Solution of H_2O and Sulfuric acid Volt Meter Single pole knife switch WHEN THE SWITCH IS PRESSED THE NEEDLE WILL MOVE INDICATING A FLOW OF ELECTRONS	What is a wet (voltaic) cell? How does a voltaic cell operate? How might we build a simple voltaic cell? How can we find out?

	What two forms of matter are used as conductors in this simple cell? (metals and an acid) What kind of action is taking place? (chemical)
Insert a small light bulb in the circuit and close the switch.	What do you expect to happen? What did happen? Why? What type of transformation have you noticed?

Summary Statement: Chemical energy can be transformed into electrical energy.

Auxiliary Words: chemical energy, matter, conductor, chemical action

References: Brandwein, Paul F., et al., Exploring the Sciences. New York: Harcourt, Brace and World, 1964.

Stone, G. K., and Stephenson, L.W., Science in Action. Englewood Cliffs: Prentice-Hall, Inc., 1966.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy can be changed from one form to another.

Title: Electric energy can be made from chemical energy

ACTIVITY	QUESTIONS
	What are some of the ways we produce electricity? (generators, atomic, photo-electric cells, stress the cell approach)
Have several groups break up a dry cell (flashlight battery).	
Examine the metal-like shell or container.	What is this outside shell made of? (metal) How do you know?
Add a few drops of acid (any dilute--H_2SO_4, HCl, etc.) to the metal shell.	
Treat a piece of Zn, Al, and Cu with the same acid.	What do you see? (bubbles) What happens? What did we learn? (The container is probably made of Zn.)
Try to develop the idea that the cell probably contains some acid.	
Wet some red and blue litmus paper and press against the black powder inside the cell.	What does the color change in the litmus paper indicate?
	What is the composition of this material in the center of the cell? How can we find out?
Test this with acid.	(An acid reacting with a metal will show bubbling reaction.) What then are the essential parts of electrical cells? (a metal (Zn), a nonmetal (C), and a acid) (or a metal (Zn), a less active metal (Cu) and an acid)
Let us make an electric cell. Materials required: metal strips of various metals about 1" x 6" (Zn, Al, Fe preferred), piece of carbon (the old cell center) post, a graphite pencil from a carbon-arc lamp, a piece of	

"Pb" from a pencil (stripped of wood, of course). An acid (HCl, etc. from the lab, vinegar from home), a beaker, some connecting bell wire.

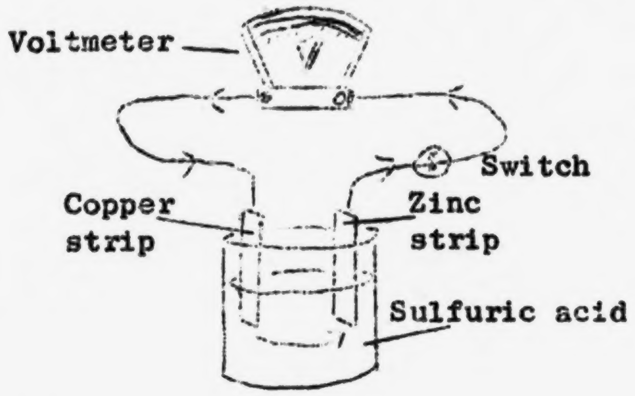
Use a galvanometer, a sensitive ammeter or a compass wrapped with wires.

Additional Activities: Change polarity and note change of direction of needle deflection. Use various metal combinations. Look up electrodes, electrolytes.

Materials needed: copper strips, zinc strips, solution of dilute sulfuric acid, bell wire, galvanometer, beakers or other glass containers

Students can make a simple cell by placing a copper strip and a zinc strip in a solution of dilute sulfuric acid. Connect the zinc and copper strips to a switch and a meter by using bell wire.

Illustration:



WHEN THE SWITCH IS PRESSED THE NEEDLE WILL MOVE INDICATING A FLOW OF ELECTRONS

What evidence do we have that electricity is being produced? (either none or bubbles from the metal)
How can we scientifically demonstrate that we are producing electricity?

How do we know electricity is being produced? (deflection of needle)

Insert a small light bulb in the circuit and close the switch.	What two forms of matter are used as conductors in this simple cell? (metals and an acid) What kind of action is taking place? (chemical) What do you expect to happen? What did happen? Why? What type of transformation have you noticed?

Summary Statement: Electricity can be produced by a chemical reaction.

References:

Brinceith, Richard, et al., The Physical World. 2nd Edition. New York: Harcourt, Brace and World, 1963.

Dull, Charles, et al., Modern Physics. New York: Holt, Rinehart and Winston, 1964.

Mattinson, Ges, et al., Science 6. Morristown: Silver Burdett Company, 1965.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

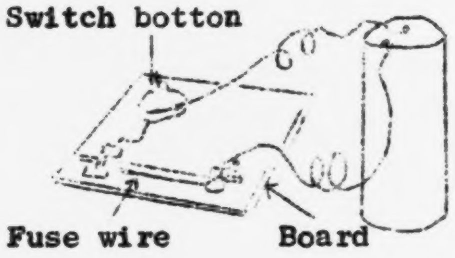
Concept: Energy can change from one form to another.

Title: Electrical energy to heat and light energy

ACTIVITY

Connect a piece of fuse wire between clips, as in diagram below.

Illustration:



WHEN THE SWITCH BUTTON IS PUSHED, THE FUSE WIRE MELTS

The fuse wire should have a rating of two amperes.

Caution

Never use house current for this activity, use only 1½ volt dry cells. Have students press the button and observe what happens. The students should see a flash of light as the fuse wire melts.

Optional Activity: Use broken bulb with filament intact to show heat.

QUESTIONS

What form of energy does the battery possess?
What happens to this form of energy?
How was the fuse wire affected?
How many different types of energy change did you notice?
What are they?

Summary Statement: Electrical energy can be changed into heat and light energy.

Concept Term: energy change

Auxiliary Word: energy

References:

Brandwein, Paul F., et al., Exploring the Sciences. New York: Harcourt, Brace and World, 1964.

Lehrman and Swartz, Foundations of Physics. New York: Holt, Rinehart and Winston, 1965.

Metcoffe, Clark H., et al., Modern Physics. New York: Holt, Rinehart and Winston, 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy can be changed from one form to another.

Title: Mechanical energy to heat energy.

ACTIVITY	QUESTIONS
This may be a demonstration activity depending on materials available. The device needed will be a small bicycle tire pump.	
Have students examine the tire pump.	What is this device called? What is the purpose of this pump? What kind of energy is needed to operate this pump?
Have one or more students operate pump. Instruct them to pump as rapidly as possible.	What do you feel coming out of the nozzle of the pump? How does it feel?
Have one or more students feel the piston of the pump immediately after someone has stopped pumping.	How does the handle feel? (warm or hot) Why? Where did the energy for this heat come from? What energy transformation has been shown here?
Additional Investigation: Have students use books, magazines, etc. to list other machines or devices which change mechanical energy to heat energy energy.	

Summary Statement: The application of mechanical energy produces heat.

References:

Jacobson, Willard J., et al., Investigations in Science. New York: American Book Company, 1965.

Pella, Milton O. and Wood, Aubrey, Physical Science for Progress. Englewood Cliffs: Prentice-Hall, Inc., 1964.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Molecular motion (kinetic energy) can be altered by the absorption or release of energy.

Title: Heat VS temperature

ACTIVITY	QUESTIONS
Materials needed: three pans 8" to 12" in diameter or square, centigrade thermometers, boiler or source of hot water, ice cubes, beakers, etc.	
Have three pans partially filled with water one at about 70°C, one with tepid water about 40°C and one at about 15°C (let several ice cubes dissolve in tap water).	How can you be sure which is hot, which is cold?
Have several students (one at a time) place their left hand in the cold water, their right hand in the hot water. Now both in the middle (tepid) pan.	To which hand does the water in the middle container feel hot? To which hand does it feel cold? Why? Why do scientists need instruments in order to measure "hot" and "cold" accurately? What instruments do we use? (thermometers)
Have students pour a measured amount of hot water (with care) on an ice cube, an equal amount of tepid water on an ice cube and an equal amount of cool water on a similar ice cube.	Which cube melts fastest? Why?
Repeat, using a measured volume of hot water (90° to 100° C) and four times as much luke warm water.	Repeat above questions. Why did the luke warm water melt the ice cube faster than the hot water? What factor other than temperature (quantity of heat) seems to be important in measuring heat? How can we find out?

Measure exactly 200 ml of hot water and 200 ml of cold water into beakers. Measure the temperature of each, using separate thermometers. Pour carefully together into a large insulated beaker or calorimeter. Using the two thermometers as mixing paddles, measure the temperature of the resulting mixture.

Make several trials if time permits and average the results.

What was the resulting temperature? How much did it vary from the temperatures of water with which we started?

What do you think happened to the molecules in the hot water?
(slowed down)
What probably happened to the motion of the molecules in the cold solution? (speeded up)
Why? (transfer of energy)
What would have been the result if the volumes of water had been unequal?
How would you find out?

Summary Statement: Temperature is a measure of the average motion of molecules, where as heat is the total quantity of motion of all the molecules of a substance.

Concept Term: heat

Reference: Beauchamp, Wilbur L., et al., Science is Understanding. Chicago: Scott, Foresman and Company, 1964.

Boylan, Paul J., Elements of Physics. Rockleigh: Allyn and Bacon, Inc., 1962.

Dull, Charles, et al., Modern Physics. New York: Holt, Rinehart and Winston, 1964.

Mallinson, George G., et al., General Physical Science. New York: McGraw-Hill Book Company, 1961.

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Molecular motion (kinetic energy) can be altered by the absorption or release of energy.

Title: Transfer of energy

ACTIVITY	QUESTIONS
Have students do as many as possible of the following or similar activities. After each activity, ask the suggested questions.	
1. Suspend several small balls by equal lengths of string from the same point. Hold one ball to one side and release. Repeat in various combinations.	What caused the particles (balls, molecules) to move? Where did the energy come from? What happens to the particles when they are no longer absorbing energy? Why? What happens to the particles when they have released their energy? What happens to the energy which they release? What can we call the energy possessed by particles in motion? (kinetic)
2. Heat a beaker of water containing visible particles, such as glass beads, sawdust, dye, etc.	
3. Place bits of sawdust or other particles on the head of a vibrating drum or stretched piece of rubber.	
4. Touch a vibrating tuning fork to the surface of a pan of water.	

Summary Statement: Motion is usually increased when energy is absorbed and decreased when energy is released.

Concept Term: kinetic energy

Brandwein, Paul F., et al., The World of Matter and Energy. New York: Harcourt, Brace and World, 1964.

Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Molecular motion (kinetic energy) can be altered by the absorption or release of energy.

Title: Heat transfer

ACTIVITY	QUESTIONS
Have each group of students heat a container of water to boiling. Have second container with measured (about 200 grams) amount of tap water at room temperature. Measure the temperature of the tap water. Hang a piece of iron (tap, bolt, etc.) in the boiling water for several minutes so that it is submerged, but not touching bottom.	What is happening to the iron?
Have students transfer the iron quickly to the tap water and stir gently until temperature becomes stable. Record new temperature.	How has the temperature of the tap water changed? What caused the increase in temperature of the tap water? How much was the temperature of each gram of tap water increased? How much heat was transferred from the boiling water to the tap water by the iron?
Students may need to do research.	What temperature change would you expect if you had used only half as much water? Why?
Optional: Have students plan and carry out an investigation to compare specific heat capacities of lead, copper and other metals.	

Summary Statement: The motion of molecules is increased by the absorption of energy.

Concept Term: kinetic molecular motion

References:

Brandwein, Paul F., et al., The World of Matter and Energy. New York: Harcourt, Brace and World, 1964.

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Molecular motion (kinetic energy) can be altered by the absorption or release of energy.

Title: Energy is absorbed

ACTIVITY	QUESTIONS
Note to Teacher: This activity should be done by one group of students as a demonstration. Pour about a pound of lead shot into a beaker or other container. Measure and record its temperature as accurately as possible. Place shot in an empty cardboard tube and seal both ends with tape. Stand tube vertically on table, grasp both ends firmly, and invert quickly. Repeat process about 50 times. Open one end of the tube and measure and record the temperature of the shot.	What change, if any, did you observe in the temperature of the shot? Where did the heat energy come from? What were the various energy conversions that took place during the process? What is done when energy is transferred from one place to another?

Summary Statement: Absorption of energy usually results in an increase in temperature caused by an increase in molecular motion.

References:

Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Molecular motion (kinetic energy) can be altered by the absorption or release of energy.

Title: Molecular motion and phase of matter

ACTIVITY	QUESTIONS
Place on demonstration table before students two large beakers. Fill one with water - the other with ice.	What is the difference between these two substances? Why does the ice maintain its shape?
Note to Teacher: Students may need to use references.	What will cause the ice to melt? Why?
Have each group of students observe one or two ice cubes as they melt in a beaker and record the temperature at regular intervals.	At what temperature do the molecules in ice seem to be moving fast enough to become a liquid?
Have students heat the water from the melted ice and record the temperature until the boiling point is reached.	At what temperature do the molecules in water seem to be moving fast enough to become a gas? What factor seems to determine the physical state or phase of matter? Why?

Summary Statement: The physical state of matter is dependent upon the amount of heat energy present.

References:

Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Once an object is in motion, it tends to remain in motion, unless energy is used to produce an unbalanced force.

Title: Molecular motion due to energy

ACTIVITY	QUESTIONS
Materials: Brownian movement apparatus or milk, water, light source, and microscope (highpower)	
Set up Brownian movement apparatus as per instructions, or add 3 parts of water to one part milk and place on a glass slide under a microscope.	What do you see? What is needed to move these particles? Why do the particles keep moving? What is needed to stop these particles? What causes the particles to change direction so often? What would happen to the speed of these particles if they were heated?
Warm the slide of milk.	What do you observe about the speed of the particles? Why? How might we slow or stop the particle motion?

Summary Statement: Objects in motion tend to remain in motion in a straight line unless energy is used to produce an unbalanced force.

References:

Abraham, Norman, et al., Interaction of Matter and Energy. New York: Rand McNally and Company, 1966.

Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Once an object is in motion, it tends to remain in motion; unless energy is used to produce an unbalanced force.

Title: External forces and the pendulum

ACTIVITY	QUESTIONS
Materials needed: length of string, metal weight, or large one-hole rubber stopper, meter stick	
Have each group of students construct a pendulum, the length of the string and the size of the weight is not important here. Mount large sheet of paper behind it. Let the pendulum hang straight and make a mark on the paper to indicate its resting point. Now have students raise the pendulum to a height (arc height) and record it.	How high did you raise your weight from the table? What did you use to raise it to this height? What does the weight now possess? What will the weight do when we release it? Why?
Let pendulum swing and record the maximum height to which it swings.	How high did the weight swing? How does this compare to the height at which you started? Why are these heights similar?
Now have each group of students swing their pendulum. The groups may vary the heights at which they start the pendulum swinging. Trace the energy condition of the pendulum as it swings back and forth and record the time it takes for the pendulum to stop.	What is needed for the pendulum to swing back? Where does it get this energy? Why does the pendulum remain in motion for a long time? What factors eventually cause the pendulum to stop? What do you have to do to keep the pendulum in motion?

Summary Statement: A moving pendulum remains in motion until energy is used to produce an unbalanced force.

References:

Abraham, Norman, et al., Interaction of Matter and Energy. New York: Rand McNally and Company, 1966.

Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Once an object is in motion, it tends to remain in motion, unless energy is used to produce an unbalanced force.

Title: Falling objects

ACTIVITY	QUESTIONS
Have students suspend a 1.0 kg weight from a spring balance and note and record the scale reading as the weight is lifted steadily from the floor to a height of 2 meters.	How much work have you done? How much potential energy does the weight have at the 2 meter height?
Have students lower weight slowly and steadily to floor from 2 meter height, noting and recording scale reading.	Why was a force necessary in order to lower the weight slowly? How much potential energy does the weight have now, with respect to the floor?
Have students suspend the 1 kg weight from a stationary support 2 meters above the floor. Place a box of sand on the floor beneath the weight.	When the weight is released, what energy changes will occur?
Release weight and allow to fall freely into sand box.	How much kinetic energy did the weight possess at the moment of impact? What caused the weight to stop? What happened to the kinetic energy possessed by the weight as it was being stopped?

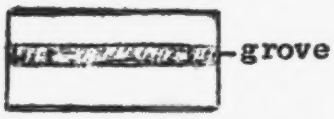
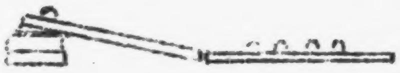
Summary Statement: Energy is used to set an object in motion and to change its motion.

Reference: Marean, John H. and Ledbetter, Elaine W., *Physical Science, A Laboratory Approach.* Reading: Addison-Wesley Publishing Company, 1968.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Once an object is in motion, it tends to remain in motion, unless energy is used to produce an unbalanced force.

Title: The forces needed to stop an object in motion

ACTIVITY	QUESTIONS
Materials needed: marbles, metal balls, a grooved wooden plank Have the Industrial Arts department groove two planks of wood which will serve as a track and set up as follows:  	
Incline one board and place the other flat so that the grooves match. In the groove of the board which is flat, place four or five marbles next to each other. Allow a marble to roll down the board and hit the four marbles.	What did the moving marble possess? Why did it stop? What happened to the end marble? Why? What will happen to the end marble if a metal ball replaces the moving marble?
Roll the metal ball down the track and hit the four marbles.	What happened to the end marble? Why did the end marble move further this time? Which object, the rolling marble or metal ball, needed more energy to stop it? How do you know?
Optional: Vary the height of the board.	

Summary Statement: The amount of force needed to stop an object in motion is dependent on the mass and velocity of the object.

References:

Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy gotten out of a machine does not exceed the energy put into it.

Title: Using the meter stick as a balance

ACTIVITY	QUESTIONS
Materials needed: meter stick, weights, fulcrum and attachments.	
Balance the meter stick first then give the students a 10 gm weight and attach it to one end of the meter stick and ask them to balance it using another 10 gm weight.	What did you do in order to balance the meter stick? What is the distance from the balance point to the first 10 gm weight? What is the distance from the fulcrum to the other 10 gm weight? How do these distances compare? How could we balance a 20 gm weight by using only a 10 gm weight?
Have students again balance meter stick using a 10 gm and 20 gm weight.	What is the distance from the 10 gm weight to the fulcrum? What is the distance from the 20 gm weight to the fulcrum? How do these distances compare?
Have students repeat using 10 and 30 gm weights, 10 and 40 gm weights until they are able to predict a ratio between weight and distance from fulcrum.	

Summary Statement: The work put into a lever does not exceed the work output.

References:

Marean, John H. and Ledbetter, Elaine W., Physical Science, A Laboratory Approach. Reading: Addison-Wesley Publishing Company, 1968.

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy gotten out of a machine does not exceed the energy put into it.

Title: Investigation of the laboratory balance

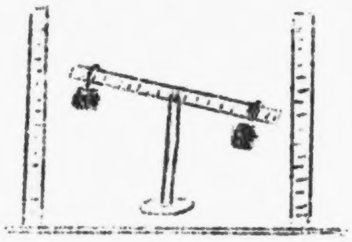
ACTIVITY	QUESTIONS
Material used: balance, meter stick, fulcrum and weight	
Have students look at a laboratory balance.	How is the balance similar to the meter stick balance? How is this balance different from the meter stick balance?
Have students put weights on the balance so they can see that the distance to the fulcrum does not change.	Why must we use a 20 gm weight to balance another 20 gm weight? What does not change? What do we use this balance for?
Give students an object to weigh and have them try to weigh it on both the laboratory balance and the meter stick balance.	Which machine was easier to use in weighing the object? What, then, could we use the meter stick balance for?
Set up a lever and fulcrum under a table or other heavy object so that a girl could easily lift it by stepping on the end. Then move the fulcrum so that a boy, using the lever, can not lift the table. Have students observe the distance of the table from the fulcrum.	Why could the girl lift the table and not the boy? What was the board being used as? What are some uses of a lever?

Summary Statement: A lever can be used to lift heavy objects with very little effort.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy gotten out of a machine does not exceed the energy put into it.

Title: Working with a simple machine

ACTIVITY	QUESTIONS
Materials needed: 3 meter sticks (one of which will serve as a lever), fulcrum, assorted weights	
Set up apparatus as shown: 	
Balance the heavier weight with a lighter weight. Have students lower the end of the meter stick with the lighter weight. Measure the distances the two ends are moved. Do this with different combinations of weights and construct a table of the distances.	As the lighter weight was lowered, what happened to the heavier weight? Which weight moved through a greater distance?
Teacher should call the weight being raised the "resistance" and the weight doing the raising the "effort."	What did we gain in using this lever? (effort is less) What did we lose in using this lever? (distance effort moves) How can we find out how much work was done?
Refer students to activities in Scheme 4 in which work is equal to the distance the object moves times its weight.	How much work was done in lowering the effort? How much work was done in raising the resistance?

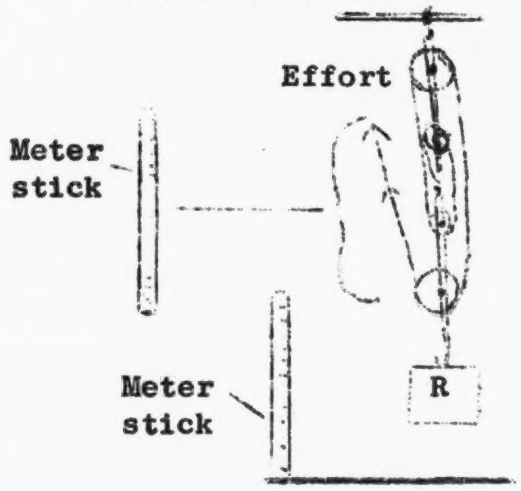
	How do these answers compare? (they are the same) How much energy was saved in doing this work? (none)

Summary Statement: The lever does not increase the energy put into it.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy gotten out of a machine does not exceed the energy put into it.

Title: **Pulleys**

ACTIVITY	QUESTIONS
Materials needed: set of weights, meter sticks Note to Teacher: If students are not familiar with the pulley, do the activity on page 49 of Volume III of the St. Mary's Curriculum Guide. Set up pulley system as shown: 	
Have students lift a resistance through a set distance (5 cm) and measure the distance through which the effort moved. Have them vary the resistance and record all distances moved and efforts required.	How much force was required to lift each of your resistances? Which had to move further, the resistance or the effort? How much work did the double pulley save you? (none) How might we find out?
Have students compute the work done in raising the resistance (W = Resistance times the distance resistance moves) and the effort (W = effort times the distance the effort moved)	

How does the work done in raising the resistance compare to the work done in moving the effort?
Why does the work put into the machine exceed the work output? (friction)
What is the only thing we gained with the double pulley? (force)
Why is this force less than the weight of the resistance? (each string supports or shares part of the resistance)

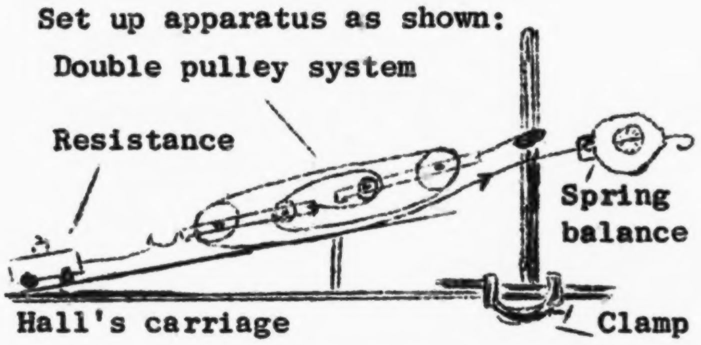
Summary Statement: A system of double pulleys can be used to increase force with a resulting loss in distance the force moves.

Reference: Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: ENERGY MAY BE TRANSFORMED; IT IS NOT CREATED OR DESTROYED.

Concept: Energy gotten out of a machine does not exceed the energy put into it.

Title: A compound machine

ACTIVITY	QUESTIONS
Materials needed: a smooth board, two double pulleys, meter stick, spring balance, weights, toy truck or Hall's Carriage	
Note to Teacher: Review the activity on page 56, Volume III of curriculum guide.	
Set up apparatus as shown:  Double pulley system Resistance Spring balance Hall's carriage Clamp	
Have students weigh the toy truck and weight. Measure the length of the plane. Then set up the compound machine as shown.	How many simple machines do we have? What are they?
Have students pull cart up the inclined plane using the pulley system. They should measure and record the distance the spring balance (effort) moves.	How much effort was needed to lift the resistance? How far did the effort have to move? (length of plane plus measured distance of string)
Have students move cart along the length of the inclined plane. Record the effort.	How far did the effort move? (length of plane) What was the effort?
Students should now move cart using the pulley system as in the previous activity.	

How far did the effort move?
What was the effort?
Why was the effort less when we used the inclined plane and pulley system?
What are some other machines which are really combinations of two or more simple machines?
What are these machines called? (compound or complex)
If the machine we use gains in force, what do we lose? (distance)
If the machine we use gains in distance, what do we lose? (force)

Summary Statement: Compound machines are composed of two or more simple machines.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: All living things are affected by their environment.

Title: Heating radish seeds

ACTIVITY	QUESTIONS
Have students bring radish seeds, small containers for planting, and soil to class. Have thermometers available. Have students observe seeds.	What do we get from these seeds? What could we do to these seeds to get radish plants?
	How would the germination of these seeds be affected if the temperature were very hot here in the room? How could we find out?
Students may suggest applying heat to the seeds. (oven, water bath, or incubator)	What could we do to compare heated seeds with non-heated seeds?
Students may suggest separating seeds and heating some and not heating others. Note to teacher: Develop idea of controls.	How many seeds should we heat? How many should we leave at room temperature? Why?
It is suggested that 10 seeds be heated and 10 seeds left at room temperature for each student. Note to teacher: Develop the idea of reliability.	How long should we heat the seeds? How can we find out what the temperatures are where we are heating our seeds? What temperatures should we record? Why?
Time may vary--ten minutes is suggested. Have students heat 10 seeds. Have students leave 10 seeds at room temperature. Record the temperatures. Have students plant all seeds and label them in the soil containers. Allow three-five days for the germination of seeds. Water daily.	

What happened to the seeds that were heated?
What happened to the seeds that were not heated?
How does the heating of radish seeds affect their germination?
How do you know?
What other environmental conditions may affect germination of seeds?

Additional Activities: Read about the germination of seeds. Some students may try other types of seeds at specific temperatures.

Summary Statement: The heating of radish seeds may influence their germination.

Concept Term: environmental factor

Auxiliary Words: germination, control, reliability

References:

Baker, Arthur O., et al., New Dynamic Biology. Chicago: Rand McNally and Company, 1959.

Otto, James H. and Towle, Albert, Modern Biology. New York: Holt, Rinehart and Winston, 1965.

Filmstrip, Seeds and How They Grow. Wm. Cox Enterprises, 2900 S. Sawtelle Blvd., Los Angeles, California 90025.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: All living things are affected by their environment.

Title: The effect of different environmental temperatures on radish seedlings

ACTIVITY	QUESTIONS
Have students prepare radish seedlings. Have thermometers available. Have a tight cardboard box available.	
Note to teacher: Teacher should place three separate pots of seedlings in front of class. This is to eliminate all variables other than temperature. (light and space)	
Hold a pot of seedlings up in front of class while asking the first set of questions.	Where were these seedlings grown? How normal do these plants appear? How do you think they would look if we grew them at the North Pole? Why? How do you think they would look if we grew them in a hot climate? Why? What could we do to these plants to see what would happen to them at different temperatures?
Students may suggest putting plants in a cold place such as a freezer compartment. Students may suggest putting plants in a hot place like an oven.	
	How long should we leave your plants at these different temperatures? How do we know what these temperatures are?
Have some students place one pot of seedlings in a freezing compartment of a refrigerator.	
Have some students place a second pot of seedlings in a heating unit.	

Note to teacher: The third pot of seedlings should be placed in the cardboard box to serve as a control. Reinforce idea of controls.

Optional Activity: Students may wish to expand this investigation by constructing their own method of inquiry into the effects of temperature on other kinds of plants.

What happened to the plants in the freezer?
What caused this?
What happened to the plants in the heating unit?
What caused this?

How have these plants been changed by extremes in temperature?
How do you know this?

Where could we look to see if the plants at room temperature have been affected?

Why do we need to have plants at room temperature?

What would a scientist call these plants in the box?

Of what importance is environmental temperature to a plant?
How do you know this?
How do you think other plants would be affected by the same conditions?

Summary Statement: The health of a plant is influenced by the temperature of its environment.

Concept Term: environmental temperature

Auxiliary Words: variable, control

References:

Elliot, Alfred and Ray, Biology. New York: Appleton-Century-Crofts, Inc., 1960.

Navarra and Zafforoni, Today's Basic Science Series. New York: Harper and Row, 1963.

Thurber, Walter A., et al., Exploring Science Seven. Rockleigh: Allyn and Bacon, Inc., 1965.

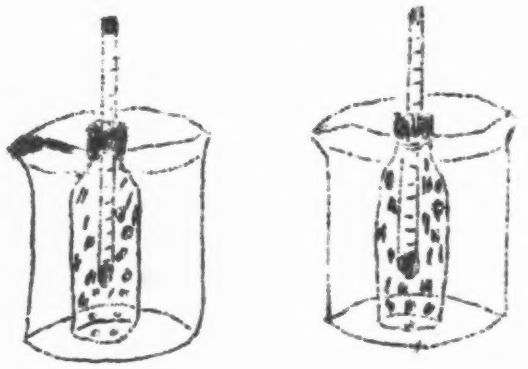
Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: All living things are affected by their environment.

Title: The effect of cold environment on insect activities

ACTIVITY	QUESTIONS
Have children bring to class an assortment of living insects in jars or bottles. (ants, wasps, flies, etc.)	
Have a number of thermometers available.	What do you observe the insects doing? How active are they? How active do you think the insects will be if we make it cold in the jars? How could we find out?
Students may suggest placing jars of insects in beakers of ice water.	How will we know how cold it is in the jars?
Students may suggest placing thermometers through holes in the tops of jars.	What are the temperatures in the jars?
	Why should we keep a record of the temperatures?
	What happened to the insects as they became colder in the jar?
	How does a cold environment affect the life of an insect?
	How does a cold environment affect the life activities of other animals?

Illustration:



TEMPERATURE INFLUENCES INSECTS

Have students look up information on how temperature affects cold-blooded animals.

Summary Statement: Insect activities are slowed down in cold environments.

References:

Branley, Franklyn M., et al., The World of Life. New York: Ginn and Company, 1965.

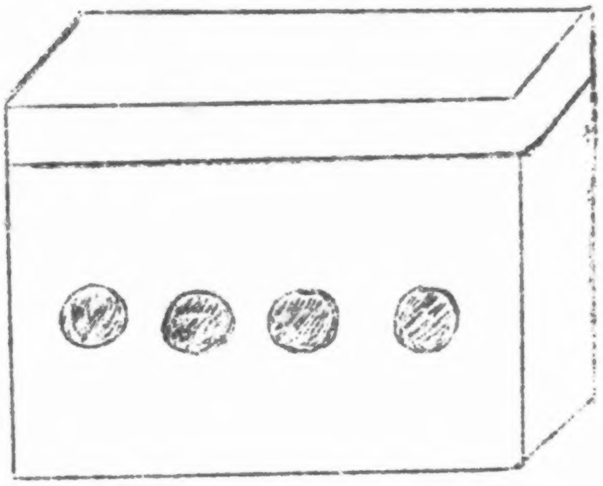
Brandwein, Paul F., et al., The World of Living Things. New York: Harcourt, Brace and World, 1964.

Thurber, Walter A., et al., Exploring Science Seven. Rockleigh: Allyn and Bacon, Inc., 1965.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: All living things are affected by their environment.

Title: Insects respond to light

ACTIVITY	QUESTIONS
Materials needed: a cardboard box with cover, three pieces of different color cellophane, one piece of clear cellophane, tape, and a variety of insects.	
Each student or group of students should construct a tight box according to the following diagram.	
Illustration: 	
Place a different colored piece of colored cellophane behind each opening and fasten with tape.	How might different colors of light affect the activities of insects? What colors of light would best attract insects? How could we find out?

Have each student or group of students place their insects in their box and place the box near a light source.

After ten minutes count the number of insects before each different color of cellophane.

Have students cover the color to which most of the insects were attracted.

Discuss the effect of light on feeding habits of animals, reproduction, and migration.

Optional Activity: Students may keep earthworms in wet sphagnum moss in a dark box. Suddenly lift the cover and direct a beam of light from a flashlight on the anterior region of the worms. Observe their reactions.

You may try this activity with planaria and fruit flies and note the response to light.

To which color was the greatest number of insects attracted?

What do you think would happen if we covered that color?

To which color are the insects attracted now?

What are some ways that light affects insects in every day life?

How does light affect other types of animals?

Summary Statement: The activities of animals are affected by light.

References:

MacCracken, Helen Dolman, et al., Scientists at Work. Chicago: The L.W. Singer Company, 1966.

Thurber, Walter A., Exploring Science Seven. Chicago: Allyn and Bacon, Inc., 1965.

Brandwein, Paul F., et al., The World of Living Things. New York: Harcourt, Brace and World, 1965.

Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: All living things are affected by their environment.

Title: Spring blooming wild flowers

ACTIVITY	QUESTIONS
This activity is designed as a field trip, in early spring, before trees leaf out, to a wooded area where early wild flowers may be observed in bloom. If field trip is not possible bring blooming wild flowers into classroom and modify questions accordingly. While on field trip have students observe and record such data as intensity of light available to wild flowers, moisture, soil conditions, extent to which leaves have developed on plants, including trees, kinds and numbers of wild flowers blooming. Discuss the trip on the following day.	In what kind of environment did we observe wild flowers growing? Why do you think these flowers are blooming now? What environmental changes will take place when the trees leaf out? What effect will these changes have on these wild flowers?
Show the class one or more slides or pictures of an open field with summer wild flowers in bloom.	How are the plants in the open field different from those in the woods? How is the environment different from the one we visited? What environmental factors cause the plants to differ? What would probably happen if these plants were placed in the kind of environment we observed on our field trip? Why? Why do some plants bloom in the fall?

Summary Statement: Seasonal bloom of wild flowers is determined by environmental factors.

Concept Term: environment, environmental factors

References: United States Department of Agriculture, Agricultural Research Service, Special Report, Plant Light - Growth Discoveries, 1961.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: All living things depend on the environment for the conditions of life.

Title: Animals depend on oxygen for life

ACTIVITY	QUESTIONS
Materials needed: two goldfish or minnows, two containers Note to teacher: The day before this activity is to be used boil at least one quart of water. Have students observe you boiling this water. Allow boiled water to cool in a tightly closed container. Have an equal amount of unboiled water in a closed container. Refer to the fish on the demonstration table while asking the questions.	Where do fish live? How do fish breathe?
	What other aquatic life can you name that breathes in a similar way? What are the different ways aquatic life breathes? What is it that all animals get from their environments by breathing? Where do fish get their oxygen? Where does the oxygen come from that dissolves in the water? What do you think would happen if the environment of fish had no dissolved oxygen?
Hold the container of boiled water in full view of students.	What do you think has probably happened to the dissolved oxygen in this boiled water? What caused the dissolved oxygen to be driven off?
Pour an equal amount of boiled and unboiled water into two separate containers. Place a fish in each container.	What do you observe happening to the fish?
Have students describe the differences they observe in the activities of the two fish.	

Note to teacher: Place the fish from the boiled water in an aquarium when it shows signs of weakness.

Note to teacher: Teacher should discuss how water pollution may deprive aquatic life of necessary oxygen.

How was the fish affected by the lack of oxygen in its environment?

What factors other than heat will reduce the amount of oxygen available to animals living in water?

What are some examples of how fish in the water bodies of this county have been affected by water pollution?

How do you think other animals would be affected if their environments lacked oxygen?

Summary Statement: Fish are harmed by the lack of oxygen in their environment.

Auxiliary Words: aquatic, terrestrial, gills, pollution

References:

Branley, Franklyn M., et al., *The World of Life*. New York: Ginn and Company, 1965.

Davis, Ira C., et al., *Life Science*. New York: Holt, Rinehart and Winston, 1961.

Brandwein, Paul F., et al., *The World of Living Things*. New York: Harcourt, Brace and World, 1964.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: All living things depend on the environment for the conditions of life.

Title: The effects of pollutants on fish

ACTIVITY	QUESTIONS
Materials needed: household detergent, oil, potatoes, glass containers, scales, pond water, fish (minnows or goldfish)	
Place potato, detergent, oil and container of fish in front of class.	Where are these objects normally found?
	What might be the relationship of the fish to the oil, to the detergent, and to the potato?
Allow for discussion of each question.	What would happen to the fish if we were to add this detergent to the water? How do you know this?
	What would happen to the fish if we were to add oil to the water? How do you know this?
	What would happen to the fish if we were to add potato shavings? How do you know this?
Place a weighed amount of detergent in a known amount of water.	
In another container, place enough oil to cover the surface of the water. The same amount of water should be used.	
In a third container, place a weighed amount of potato shavings.	
Establish one container as a control.	
Place fish in all of the containers.	

Note to teacher: A quantitative element to this investigation may be added by timing the effect of each of the pollutants. As soon as fish show distress, remove to aquarium.

Describe the activities of the fish in each of the containers.

Students may collect items from newspapers and magazines about the problem of water pollution.

Teachers should discuss with students sewage treatment and sanitary disposal of refuse.

Students may write to their local, state, and federal agencies to obtain information on water pollution.

Optional Activity: Students may wish to investigate air pollution.

How were the activities of the fish affected by each of the pollutants?

What did the pollutants do to the water to make it unfit for life? (Prevent aeration-oxygen deprivation)

What other kinds of aquatic life are affected by water pollution?

What are some examples that you have observed of the affect of water pollution on life?

What is being done today by our local, state and federal governments to prevent water pollution?

What can we do to prevent water pollution?
What other reasons can you suggest for preventing water pollution?

Summary Statement: Man may so alter the environment that living things may be harmed.

Concept Term: water pollution

Auxiliary Words: sewage treatment, sanitation, pollutants

References: Biological Sciences Curriculum Study, BSCS Green Version, High School Biology. Chicago: Rand McNally and Company, 1963.

Fitzpatrick, Frederick L., Modern Life Science. New York: Holt, Rinehart and Winston, 1966.

Aylesworth, Thomas G., Our Polluted World. Columbus, Ohio: American Education Publications, 1965.

Filmstrip, Clean Waters. General Electric, free.

Filmstrip, Municipal Sewage Treatment Plants. U.S. Public Health, free, local health department.

Filmstrip, Pure Water and Public Health. Modern Talking Pictures Service, 927 19th Street, N.W., Washington, D.C., 20006.

Filmstrip, Collector's Item. Modern Talking Pictures Service, 927 19th Street, N.W., Washington, D.C, 20006. (Disposal of refuse in Los Angeles)

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: All living things depend on the environment for the conditions of life.

Title: Hibernation of frogs

ACTIVITY	QUESTIONS
Have container of live frogs on display when class enters room.	Where do these frogs get the energy to be so active? What is the normal diet of these frogs? What is their diet in the winter? What happens to frogs in the winter? How can we simulate their winter environment?
Line cardboard box with wet moss, place frogs in box, cover with wet moss and box lid. Place in refrigerator at temperature 40° to 45° F. for 24 hours. After 24 hours remove the frogs from the refrigerator and give each group of students a frog on a wet paper towel in a glass container immersed in ice. Have students observe frogs.	What has caused the activity of the frogs to be lessened? What relationship can you suggest between the winter activity of frogs and the food supply in their environment? What term would describe the condition of frogs in the winter months? (hibernation) What other animals can you name that hibernate in order to survive because of lack of food or other necessary environmental factors?

Summary Statement: Some animals hibernate when the environment will not support normal activity.

Auxiliary Word: hibernation

Reference: Blanc, Sam S., Fischer, Abraham S., and Gardner, Olcott, Modern Science Earth, Space and Environment. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: All living things depend on the environment for the conditions of life.

Title: Mineral deficiency in plants

ACTIVITY

Materials needed: bean seeds, distilled water, two pint jars, painted black or covered with opaque material, cheese cloth, and the following mineral solutions:

Sach's Solution

1. Dissolve in one liter of water:

Mineral Salt	Grams
KNO_3	1.0
$NaCl$	0.5
$CaSO_4$	0.5
$MgSO_4$	0.5
$Ca_3(PO_4)_2$	0.5
$FeCl_3$(1% solution)	trace (1 drop)

2. Same as above except eliminate KNO_3 which is the source of nitrogen.

Teacher may have students consult references to determine some of the required minerals needed for normal plant development. (nitrogen, phosphorous, sulfur, potassium, calcium, magnesium)

Teacher may have students discuss the need for agricultural fertilizers.

Have students weigh out the mineral salts as prescribed above. The Sach's solution will serve as the control. The students may decide to eliminate the source of nitrogen from a second solution.

QUESTIONS

How do plants get their minerals?
Why do plants need minerals?

What minerals are needed in the greatest abundance for growth of plants?

What do you think might happen to plants, if they could not obtain the necessary minerals? What could we do to find out the effects of mineral deficiency on plant growth?

Have students fill a jar to the top with Sach's solution and label. Fill a second jar to the top with the solution lacking KNO_3 and label. Place a piece of cheese cloth over the jars (fasten with rubber band) so that it lightly touches the water solution. Place bean seed on top of each jar. Observe the solutions for two weeks making sure that additional solution is added each day to compensate for evaporation and absorption.

Note to teacher: Mineral deficiencies in plants may be noticed in terms of changes of pigmentation and types of growth.

Optional Activity: Students may wish to test the effects of other mineral deficiencies by eliminating the salt sources for other elements.

Students may wish to discuss the relationship of minerals to human growth and development.

What differences do you observe in the growth of the plants grown in the two solutions?
How important do you think minerals are in the growth of plants?
What significance do you think this has for animals?

Summary Statement:	Minerals are needed for proper plant and animal growth.
Concept Term:	minerals
Auxiliary Word:	hydroponics
References:	Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958. Lee, Addison E., Plant Growth and Development. Boston: D.C. Heath and Company, 1963.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: There are characteristic environments, each with their characteristic life.

Title: Life in fresh water

ACTIVITY	QUESTIONS
	What are the different kinds of fresh water habitats in this area?
	What are some of the life forms that live in these habitats?
Have students list some of the common animal and plant members of these fresh water habitats. (frogs, protozoa, algae, dragon flies, cattails, water lilies, snails, perch, etc.)	
Have students construct several fresh water aquaria with characteristic life forms, including paramecia.	What do you think might happen if we were to place some of these life forms in other habitats? How could we find out?
Students may remove certain organisms from the fresh water aquaria and place them in different environmental situations. (saline solution, semi-arid conditions, lack of light, etc.)	What do you think might happen to the protozoa in a salt water environment? How could we find out?
Students may examine a drop of pond water. After locating paramecia, apply salt to drop of water and observe plasmolysis.	What happened to the protozoa? What does this tell you about the relationship of paramecia to fresh water? What do you think might happen to a frog in an arid habitat?
Note to teacher: Teacher may discuss the need for the frog to have fresh water for respiration and reproduction as well as other life processes. One way to illustrate the need by frogs for a water environment is to weigh a frog and then keep it out of water overnight and weigh it again. Compare the weights.	

Why are some fresh water life forms unable to live in other habitats?

Summary Statement: Some living things are adapted to fresh water environments.

Auxiliary Words: habitat, plasmolysis, protozoa

References: Baker, Arthur O., et al., New Dynamic Biology. Chicago: Rand McNally and Company, 1959.

Weisz, Paul B., The Science of Biology. New York: McGraw-Hill, 1959.

Fitzpatrick, Frederick L., et al., Living Things. New York: Holt, Rinehart and Winston, 1965.

Filmstrip, Pond Life. Encyclopaedia Britannica Films, 1150 Wilmette Avenue, Wilmette, Illinois 60091.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: There are characteristic environments each with their characteristic life.

Title: Life in the soil

ACTIVITY	QUESTIONS
Have students bring to class a coffee can full of soil that is rich in organic matter.	What environmental needs does soil provide for living things? (minerals, nutrients, water, dissolved oxygen, shelter, etc.)
Discussion should develop awareness of the soil environment for living things. (show films)	
Have students place their soil sample on newspaper and begin collecting with forceps the life forms visible to them.	
Have students organize their life forms and count the number of different organisms found.	What are the different life forms you have found in the soil?
Students may find the following visible life forms: insects, insect larvae, worms and fungal hyphae.	What other life forms are there in the soil that we can not see? How could we find out?
Note to teacher: The following microbiological investigation necessitates a full explanation in the use of the microscope and the preparation of slide cultures.	
Have students place a small amount of their top soil in a drop of distilled water on glass slide. Observe on low power without cover slip.	What forms of life do you see in the water?
Students may see a diverse realm of protists such as algae, fungi and protozoa.	
After observing on low power, students may place on cover slip for high power observation.	

Optional Activity: Students may wish to investigate the variety and abundance of life in soil poor in organic matter.

Optional Activity: Place small amount of soil in 2 ml of water. Innoculate culture dish of agar. Let stand in warm, dark place for two days and observe.

What is the relationship of the richness of the soil and the abundance of life in it?

Summary Statement: Soil provides an environment for a great variety of living things.

Concept Term: Soil organisms

Auxiliary Words: microbiology, top soil, microorganisms, fungal hyphae

References:

Thurber, Walter A., et al., *Exploring Science Seven*. Rockleigh: Allyn and Bacon, 1965.

Barnard, Darrell J., et al., *Science a Way to Solve Problems*. New York: The Macmillan Company, 1960.

Filmstrip, *The Living Soil*. Shell Oil Company, Film Library, 149-07 Northern Boulevard, New York, N.Y. 11354.

Filmstrip, *Life of the Soil*. Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: There are characteristic environments each with their characteristic life.

Title: Desert Life

ACTIVITY	QUESTIONS
Note to teacher: Order the film *The Voice of the Desert* by Joseph Wood Krutch from your local library.	What conditions would we have to have in order to construct a desert environment? (dry, hot, cold, sunny) Where on the earth are these environmental conditions found?
Students may suggest several desert areas throughout the world. The teacher may wish to furnish each student with a map of the world to be used with this activity.	What kind of plant and animals could be found in the area you named?
Students should consult several references to determine what types of plant and animal life are found in their particular area. **Optional Activity:** Students may wish to construct a terrarium illustrating the desert environment.	What are some of the unusual characteristics of the plants and animals you named? How do these characteristics enable the organism to survive in a desert environment?
Note to teacher: A full discussion can be developed on the adaptations of desert organisms to their environments by students. The teacher should have students discuss such items as root length of desert plants, conditions for seed germination, devices for conserving water, etc.	What are some other environments that have specific types of plants and animals adapted to that environment?
Suggestion to teacher: A good way of ending this activity is to show a film entitled *The Voice of the Desert* by Joseph Wood Krutch. Your local county library can help you obtain the film.	

Summary Statement: There are particular plants and animals adapted to life in the desert.

Auxiliary Word: adaptation

References:

Krutch, Joseph Wood, *The Voice of the Desert*. New York: William Sloane Associates, 1962.

Howes, Paul G., *The Giant Cactus Forest and Its World*. New York: Duell, Sloan, and Pearce, 1954.

Krutch, Joseph Wood, *The Desert Year*. New York: William Sloane Associates, 1960.

Farb, Peter, *Ecology*. New York: Time, Inc., 1963.

The Desert. New York: Time, Inc., 1962.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: Living things capture matter from the environment and return it to the environment.

Title: Food web

ACTIVITY	QUESTIONS
	What is a biological community? What kinds of communities can be found in our area?
Note to teacher: The class might be divided into several groups, each investigating a different type of community.	
Students should select a biological community (woodland, marsh, pond or other area) and list the inhabitants--plants and animals, including: predators, parasites, scavengers, decay bacteria and other.	
	What environmental factors are usually present in a biological community? (light, soil, air, water and living things)
Have students describe the environment of the community.	
Note to teacher: When possible, a field trip to a community and development of the list from actual observation is desirable.	
	What relationships do the members of this community have to the sun, soil, and water, etc.? (direct and indirect) What is the relationship of the community members to one another? (food web, direct and indirect relationships)
Note to teacher: Build toward direct and indirect relationships which will constitute a food web.	
Materials needed for each group of students to construct a food web: 3' x 3' peg board, pegs or hooks, thread (four colors), labels (3" x 5" cards).	

Have students construct a food web, giving the following instructions in order:

1. Have students represent the non-living environmental factors in the center of the peg board. Place the living members of the community in a circle on the edge of the board. (Use labels and pegs.) Arrangement of plants and animals is arbitrary.

2. Make the following connections between the different factors, using black thread to represent a direct relationship between non-living and living things;

   using red thread to represent a direct relationship between living and living things;

   using yellow thread to represent an indirect relationship between non-living and living things;

   using green thread to represent an indirect relationship between living and living things.

Note to teacher: The food web should be kept until the next activity has been completed.

What do you think would happen if man moved into this climax community?

Summary Statement: It is evident that living things are interdependent in a climax community.

Concept Term: food web

Auxiliary Words: climax community, predators, parasites, scavengers, decay bacteria

References:

Cornell Science Leaflet, Food Chains. Volume 55, Number 4, Spring, 1962.

Biological Sciences Curriculum Study, Biological Science: An Inquiry Into Life. New York: Harcourt, Brace and World, 1963.

Biological Sciences Curriculum Study, BSCS Green Version, High School Biology. Chicago: Rand McNally and Co., 1963.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: Living things capture matter from the environment and return it to the environment.

Title: Broken web

ACTIVITY	QUESTIONS
	What do you think would happen if one group of organisms (e.g., insects) were removed from the web?
Students may remove one group of organisms from the web. Observe the change in the structure and unity of the web.	How are other organisms in the web affected by the removal of this organism, directly or indirectly?
	What happens to the organisms that die? Why? How do you know?
	What group of organisms do you think would survive longest if the green plants were removed from the environment? (decomposers)
Remove green plants from the food web and observe the effect on the food web.	What group of organisms would be affected first? How can you explain the gradual extinction of various animals in nature? What group of organisms would be the last to be affected? How does man's actions affect the dynamic equilibrium of the food web?
Note to teacher: The terms "dynamic equilibrium" and "balance of nature" are used synonomously and this may be the place to develop the concept of nature's balance.	

Summary Statement: Nature maintains a dynamic balance.

Concept Term: dynamic equilibrium

Auxiliary Words: decay bacteria, extinction

References:

Biological Sciences Curriculum Study, BSCS Green Version, High School Biology. Chicago: Rand McNally and Company, 1963.

Cornell Science Leaflet, Food Chains. Volume 55, Number 4, Spring 1962.

Fitzpatrick, Frederick L., Living Things. New York: Holt, Rinehart and Winston, 1962.

Conceptual Scheme: LIVING THINGS INTERCHANGE MATTER AND ENERGY WITH THE ENVIRONMENT (AND WITH OTHER LIVING THINGS).

Concept: Living things capture matter from the environment, and return it to the environment.

Title: The source of matter for living things

ACTIVITY	QUESTIONS
	What are living things composed of? (Help students develop the concept that living things can be classified as "matter".)
	What are the basic materials that all matter is composed of? (elements)
	What are the elements that living things are composed of?
Prepare ditto copies of the attached chart and distribute to each student.	How do animals obtain these elements? (The answer you will eventually get is food.)
	What is food? (The bodies and products of plants and animals)
	Plants don't eat. Where do they obtain these elements?
After discussion, show: (1) a container of water, (2) a pile of soil, and (3) a balloon filled with air to represent the sources of the elements (matter) to plants and, subsequently, to all living things.	
Note to teacher: The concept that the students should have at the conclusion of this activity is that living things are composed of certain elements, the ultimate source of which is the non-living environment -- the soil, the air, and the water.	

Summary Statement: Living things are matter and are composed of about 20 elements which are common to both living and non-living things. The non-living sources of these elements to living things are the soil, the air, and water.

Auxiliary Words: matter, element, environment

References:

Buchsbaum, R. and M., Basic Ecology. Pittsburgh: The Boxwood Press, 1957.

Odum, E.P., et al., Fundamentals of Ecology. Philadelphia: W.B. Saunders Company, 1959.

A TABLE OF ELEMENTS MOST COMMON IN LIVING THINGS

ELEMENT	SYMBOL	APPROXIMATE % (BY WEIGHT) OF A MAN	APPROXIMATE % (BY WEIGHT) OF A CORN PLANT	
Oxygen	O	65.0	75.0	
Carbon	C	18.0	13.0	
Hydrogen	H	10.0	10.0	
Nitrogen	N	3.3	0.45	
Calcium	Ca	1.5	0.07	MINERALS
Phosphorous	P	1.0	0.06	
Potassium	K	0.35	0.28	
Sulfur	S	0.25	0.05	
Sodium	Na	0.24	Trace	
Chlorine	Cl	0.19	0.04	
Magnesium	Mg	0.05	0.06	
Iron	Fe	0.005	0.03	
Manganese	Mn	0.0003	0.01	
Silicon	Si	Trace	0.36	

Most of these elements occur only in compounds.

Conceptual Scheme: LIVING THINGS INTERCHANGE MATTER AND ENERGY WITH THE ENVIRONMENT (AND WITH OTHER LIVING THINGS).

Concept: Living things capture matter from the environment, and return it to the environment.

Title: Green plants use CO_2 and H_2O to make starch

ACTIVITY	QUESTIONS
Note to teacher: Review previous exercise and have in front of the students the containers of soil, water, and air and the chart from the previous exercise.	The majority of the weight of the corn plant and the human is made up of which four elements?
	What are good sources of these elements in the environment? (carbon, hydrogen, oxygen, and nitrogen)
Note to teacher: The discussion should lead to CO_2 in air, H_2O, N_2 in air.	How do plants obtain these elements from these sources?
Note to teacher: Discussion should lead to the concept of photosynthesis.	
Put on the black board: $\underset{\text{carbon dioxide}}{6CO_2} + \underset{\text{water}}{6H_2O} \xrightarrow[\text{(light)}]{} \underset{\text{glucose (sugar)}}{C_6H_{12}O_6} + \underset{\text{oxygen}}{6O_2}$	
Discuss. Set up the following to show that green plants need and use water and carbon dioxide from the environment to make starch.	
Materials: 4 healthy green geranium or coleus leaves, six 50 ml beakers or small baby food jars, 4 glass containers with lids (like wide-mouth gallon jars), 200 ml beaker, Bunsen Burner, tripod, water bath or pan, 5% baking soda solution, iodine, alcohol, sodium hydroxide pellets	
1. Letter four 50 ml beakers A, B, C, and D and put a healthy green geranium or coleus leaf in each.	

2. Fill beakers A and B 3/4 full with water so that petiole is in water. Add nothing to beakers C and D.

3. Add about 1/2 inch of sodium hydroxide pellets to the remaining two 50 ml beakers.

4. Letter the four one-gallon jars A, B, C, and D.

5. Place the four beakers with plants in corresponding gallon jars. (A in A, B in B, etc.)

6. Place a 50 ml beaker with sodium hydroxide pellets in jars B and D also.

7. To jars A and C add 5% solution of baking soda in water, to a depth of 1 inch. Avoid getting any on the leaves or in the beakers containing them. Close the jars tightly.

8. To jars B and D add water to a depth of 1 inch. Close the jars tightly.

9. Put all four jars in a well lighted place, but not in direct sunlight.

10. After 48 hours remove the leaves from their individual containers and test for starch by removing chlorophyll from leaves by boiling in alcohol and then flooding with iodine. If the leaf turns blue-black, starch is present.

Note to teacher: Results should be positive for starch in the leaf in jar A only because it is the only one which has both CO_2 and H_2O. CO_2 is produced by the baking soda solution. CO_2 is absorbed by sodium hydroxide pellets.

In which leaf was the starch test positive?
What environmental factors are present in container A that are absent in the others?

From this experiment what environmental factors would you conclude to be necessary for the plant to make starch?

What elements are contained in CO_2 and water?

Where are CO_2 and water normally found in our environment?

Summary Statement: Green plants obtain the elements carbon, hydrogen and oxygen from water and carbon dioxide. These are captured through the process of photosynthesis.

Auxiliary Term: photosynthesis

Reference: Mason, John M. and Peters, Ruth T., Life Science: A Modern Course. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: LIVING THINGS INTERCHANGE MATTER AND ENERGY WITH THE ENVIRONMENT (AND WITH OTHER LIVING THINGS).

Concept: Living things capture matter from the environment and return it to the environment.

Title: **The capturing of nitrogen**

ACTIVITY	QUESTIONS
Note to teacher: This exercise must be set up six weeks before it is needed.	
Materials: soy bean seeds, innoculant for soy beans which contains the nitrogen-fixing bacteria (can be purchased from a seed store, such as Maryland Tobacco Growers' Association), flower pots or similar containers, vermiculite, water	
Procedure:	
1. Soak seeds for two minutes in water. Remove, divide into two groups, and dust one group with the innoculant. Plant both groups in separate pots of vermiculite.	
2. Keep the vermiculite moist with water throughout the experiment.	
Six weeks later---The observing and completing of this activity should follow the previous activity.	
Refer again to the chart of elements found in living things, reviewing also how plants obtain carbon, hydrogen and oxygen from the environment.	How are elements other than these three obtained by plants?
Recall the procedure used six weeks ago to set up this experiment. Direct students to compare the two groups of plants.	In what ways are the two groups of plants different? Which group of plants appears to have more luxuriant growth?

Instruct the students to pull up the plants and compare the roots.

Students should now become involved in a library research activity to find the answers to these and previous questions. Topics they should be involved with would include: legumes, nitrogen-fixing bacteria, the nitrogen cycle, etc.

In what ways are the roots different?

What is the variable in this experiment?

What is a possible cause of these root nodules?

To what would you attribute the more luxuriant growth of this group of plants?
Why?

What is the source of free nitrogen?
What must happen to atmospheric nitrogen before green plants can use it?
What kind of living things are responsible for changing atmospheric nitrogen into a usable form?
Where does this process usually take place?
What are the nodules that grow on the roots of legumes?
Why do green plants need nitrogen?

Summary Statement:	Atmospheric nitrogen which is not usable by most plants is changed into a usable form by certain soil organisms.
Concept Terms:	nitrogen cycle, nitrogen fixation, nitrogen-fixing bacteria
Reference:	Mason, John M. and Peters, Ruth T., Life Science: A Modern Course. Princeton: D.Van Nostrand, 1965.

Conceptual Scheme: LIVING THINGS INTERCHANGE MATTER AND ENERGY WITH THE ENVIRONMENT (AND WITH OTHER LIVING THINGS).

Concept: Living things capture matter from the environment, and return it to the environment.

Title: The capture of mineral elements

ACTIVITY	QUESTIONS
Refer to the chart which lists the elements that living things are composed of. Direct the students to the group of elements indicated as minerals.	From what source do plants obtain the elements classified as minerals? If a farmer planted a crop in a field and harvested it and repeated this year after year, what would happen to the mineral content of the soil? How do farmers restore the mineral content of the soil?
Distribute to the students the following list of the minerals contained in a commercial organic fertilizer: nitrogen, phosphorous, potassium; trace elements: iron, boron, magnesium, zinc, manganese, sulfur, calcium. Direct the students to compare this list with those elements indicated as minerals as in the chart of elements found in living things.	What is the purpose of adding fertilizer to soil? What is organic fertilizer made from? What is the inorganic source of the minerals contained in this fertilizer?

Summary Statement: Plants obtain the necessary mineral elements from the soil and incorporate them into their bodies as they grow.

Concept Term: mineral

Auxiliary Words: organic, inorganic, fertilizer

Conceptual Scheme: LIVING THINGS INTERCHANGE MATTER AND ENERGY WITH THE ENVIRONMENT (AND WITH OTHER LIVING THINGS).

Concept: Living things capture matter from the environment, and return it to the environment.

Title: A summary of the capture of matter by living things

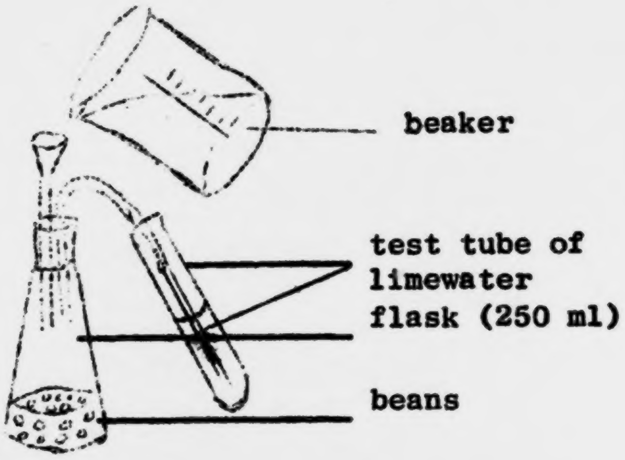
ACTIVITY	QUESTIONS
List the three categories: soil, water, and air on the chalk board. Have students refer to the chart of 18 elements found in living things and tell the source of each one.	What are the three non-living sources of matter for living things? What group of living things is the link between the non-living and living worlds--i.e., can capture matter from non-living sources and make it available to other living things? (green plants) What is the source of matter for animals?

Summary Statement: Green plants secure matter from soil, air, and water and make it available to all living things.

Conceptual Scheme: LIVING THINGS INTERCHANGE MATTER AND ENERGY WITH THE ENVIRONMENT (AND WITH OTHER LIVING THINGS).

Concept: Living things capture matter from the environment, and return it to the environment.

Title: How living things return matter to the environment

ACTIVITY	QUESTIONS
	What are organic substances used for by living things? How do living things get energy from organic substances? What are the waste or by-products of this energy release? How could we find out?
Students should set up the following exercise: Soak some bean seeds for 24 hours. Place them on a moist paper towel in a 250 ml flask or similar container and allow to germinate for two or three days, as shown in the diagram.	
	
Test for CO_2 by pouring water into the flask, displacing the CO_2 gas. As the CO_2 is forced out of the flask it will bubble through the limewater.	
Also have students bubble the air they exhale into limewater by using a soda straw.	What happened to the limewater? What caused this change? Where did the CO_2 come from?

Have students breathe on a cold, dry glass.

Note to teacher: At this time the teacher should summarize the capture of matter from the environment and the returning of this matter to the environment.

The release of CO_2 is the result of what process?
What other materials are released from respiration? (H_2O)

What type of living thing could use this CO_2 and water?

Summary Statement: Matter is returned to the environment by respiration.

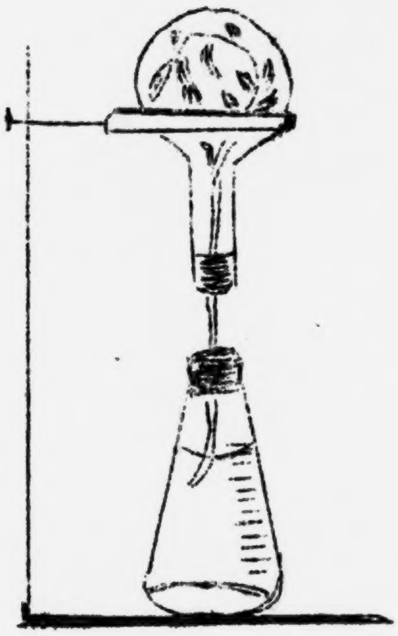
Concept Term: respiration

Reference: Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THE ENVIRONMENT.

Concept: Living things capture matter from the environment and return it to the environment.

Title: The water cycle

ACTIVITY	QUESTIONS
	Why does a plant need to capture water from the environment? How much water does a plant absorb? What happens to the water? (transpiration and assimilation) How can we investigate this?
Select the most adaptable suggestions of the students or, using illustration below, investigate transpiration and assimilation of water. A second apparatus, using a plant shoot without leaves, could be set up as a control. Set up apparatus as shown: 	
	How did the water get into the flask? How much water was removed from the graduated cylinder by the leafy shoot? How much water was collected in the flask? What happens to this water in nature? What happened to the remainder of the water taken from the graduate by the leafy shoot? When is this water returned to the environment?

How could we relate this to the cycle of water in nature?

Summary Statement: The water cycle may involve transpiration and assimilation in plants.

Concept Terms: transpiration, assimilation

References:

Biological Sciences Curriculum Study, BSCS Green Version, High School Biology. Chicago: Rand McNally and Company, 1963.

Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958.

Otto, James H. and Towle, Albert, Modern Biology. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: Living things capture matter from the environment and return it to the environment.

Title: The carbon cycle

ACTIVITY	QUESTIONS
Materials needed: candle, green plant, animal (student), limewater, decaying fruit, straw, glass jar, test tube, butter (lard)	
Place a burning candle in a jar containing a test tube of limewater; then close the jar.	How is the limewater affected? What specific changes occur? What caused this change? How do you know? What happens when you breathe into limewater?
Have students blow into limewater through a straw.	What happened when you blew into the limewater? How are you and the candle alike? (Oxidation of carbon compounds and the release of CO_2) What foods containing carbon compounds could be used to make candles?
Have students make butter candles. Burn the butter candles and test for CO_2.	What happened to the limewater? How are the butter candles different from the other candles? What living things in the environment can benefit from the release of CO_2?
Show green plant and discuss the use of CO_2 by living plants.	How is CO_2 used by plants? How does man benefit from this plant? (Man and other animals may eat it.) What happens to carbon compounds when a plant or animal dies? What reacts upon the dead organism to release carbon compounds?

Place a test tube of limewater and decaying fruit in a jar and close the lid.

Note to teacher: Allow 24 hours for limewater to turn milky in the jar with decaying fruit.

What was the relationship between the candle and the decaying fruit?

Summary Statement:	CO_2 is returned to the environment from organic material by living things.
Concept Term:	carbon cycle
Auxiliary Words:	decomposition, decomposer, oxidation
References:	Biological Sciences Curriculum Study, BSCS Green Version, High School Biology. Chicago: Rand McNally and Company, 1963. Thurber, Walter A., et al., Exploring Science. Rockleigh: Allyn and Bacon, Inc., 1965.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THE ENVIRONMENT.

Concept: Living things capture matter from the environment and return it to the environment.

Title: Carnivors eat herbivors

ACTIVITY	QUESTIONS
Have students obtain the following materials: grass sod, several small grasshoppers, and a frog or a toad.	
Note to teacher: Grasshoppers and sod should be placed in an enclosed container or vivarium two days prior to the time of investigation. Place the frog or toad in a separate vivarium without food. Be sure to allow for ventilation in both containers.	
Students should observe the organisms in the environment of the vivarium.	What have you observed the frog doing? What have you observed the grasshoppers doing? How are the environments of the frog and grasshopper different? What is the relationship between the grasshopper and the grass? Where does the grasshopper get his energy?
Place the frog with the grasshopper and allow students to observe the frog eating a grasshopper.	What happened? Why?
Discuss food chains.	What is the relationship between the grass, the grasshopper and the frog? What may happen to the frog if we return him to his natural environment? Why?

Summary Statement: Living things are interdependent in the exchange of matter and energy with the environment.

Auxiliary Words: vivarium, organism, food chain

References: Cornell Science Leaflet, *Food Chains*. Volume 55, No. 4, Spring 1962.

Fitzpatrick, Frederick L., *Living Things*. New York: Holt, Rinehart and Winston, 1962.

Moon, Truman J., *Modern Biology*. New York: Holt, Rinehart and Winston, 1960.

Conceptual Scheme: LIVING THINGS INTERCHANGE MATTER AND ENERGY WITH THE ENVIRONMENT (AND WITH OTHER LIVING THINGS).

Concept: Living things capture matter from the environment, and return it to the environment.

Title: How elements are returned to the environment

ACTIVITY	QUESTIONS
	Why isn't the surface of the earth cluttered with the bodies of dead plants and animals? How is decay useful? What happens when something decays? What causes decay? How could we investigate the decay of dead plants and animals?
Teachers should so direct discussion that the following activity can be set up. Have several dead plants and animals (insects) and plant and animal products available. Place some of each of the above items in containers of soil and water and some in open air. Be sure to keep the material in the soil and open air containers moist throughout the exercise. Observe and record data for one or two weeks, or until materials have completely decomposed.	
	What did you notice growing on the organic material? What happened to the organic materials? What do we call the action of microorganisms on organic material? (decomposition)
Note: Teacher should disect the word "decomposition", showing the meaning of each part and the total meaning.	What happened to the elements that were in the organic materials?

Summary Statement: Elements are returned to the environment by the decomposing action of microorganisms.

Concept Terms: decomposition, organic material

Auxiliary Word: elements

References:

Biological Sciences Curriculum Study, Biological Science: An Inquiry Into Life. New York: Harcourt, Brace and World, 1963.

Mason, John M. and Peters, Ruth T., Life Science, A Modern Course. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: The capture of radiant energy by green plants is basic to the maintenance and growth of all living things.

Title: Student diet

ACTIVITY	QUESTIONS
Students should list the things they ate the day before. The list should be placed on the board under two headings: Plants or Plant Products and Animals or Animal Products.	What did you eat yesterday?
Students should trace the energy in the foods, step by step, back to the original source. Several foods from each group should be used.	Why do you eat? Where did the energy in these foods come from?

Summary Statement: Organisms get their energy directly or indirectly from the sun.

References:

Fitzpatrick, Frederick L., Modern Life Science. New York: Holt, Rinehart and Winston, 1966.

Mason, John M. and Peters, Ruth T., Life Science: A Modern Course. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: The capture of radiant energy by green plants is basic to the maintenance and growth of all living things.

Title: Composition of foods

ACTIVITY	QUESTIONS
	What is food? What is food composed of? What are the compounds in food?
Have discussion on compounds in food and then distribute cereal boxes which list the percentage of fats, proteins, carbohydrates, vitamins, and minerals contained in the cereal.	What compounds did you find listed on the box? In the foods you eat how could we determine the compounds in each?
The teacher may show what the tests for fats, proteins, starch and sugar are by using the following reagents and foods: Starch test: Place a few drops of iodine on corn starch - black or dark blue color indicates the presence of starch. Sugar test: (reducing sugar, such as glucose or dextrose) Add three or four drops of Benedict's solution to the sugar dissolved in 5 ml of water. Heat the solution - an orange color indicates presence of sugar. (Benedict's solution is not a test for table sugar.) Protein test: Add 10 drops of Millon's reagent to 5 ml H_2O that contains egg white. Heat - pink color indicates the presence of protein. Fat test: Add 5 drops of cooking oil to 5 ml of water, then add 5 drops of Sudan IV and shake well. Sudan IV is a fat soluble dye and will become concentrated in the fat. If any of the above reagents are not available, contact the local high school.	

Have students test food samples for the type of compound they contain. Note to teacher: The answer to this question will be explored in the next exercise.	Which foods contain proteins? Which foods contain fats? Which foods contain starch? Which foods contain sugar? What uses are made of these compounds by living things?

Summary Statement: Foods contain compounds of fats, proteins, starches and sugars.

Concept Terms: fats, proteins, starches and sugars

Reference: Mason, John M. and Peters, Ruth T., Life Science: A Modern Course. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: The capture of radiant energy by green plants is basic to the maintenance and growth of all living things.

Title: The uses living things make of compounds in foods

ACTIVITY	QUESTIONS
This activity will be a library research activity for the students. Divide the class into five groups, each given the assignment to find out what uses living things make of the different compounds found in food: carbohydrates, fats, proteins, vitamins, and minerals and water.	The types of questions will depend upon how the teacher chooses to do this library research; therefore, they are left to the discretion of the teacher.

Summary Statement: Each type of compound of which food is composed has a specific use in the body of a living thing.

Auxiliary Terms: fats, proteins, carbohydrates, vitamins, minerals, water

References:

Mason, John M. and Peters, Ruth T., Life Science: A Modern Course. Princeton: D. Van Nostrand, 1965.

Fitzpatrick, Frederick L., Modern Life Science. New York: Holt, Rinehart and Winston, 1966.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: The capture of radiant energy by green plants is basic to the maintenance and growth of all living things.

Title: The effect of light on germination

ACTIVITY	QUESTIONS
Show pupils lettuce seeds.	How would light affect germination in these seeds? How can we investigate this?
Materials for each group of students: petri dish paper towels scissors 1 pkg. Grand Rapids lettuce seeds 1 pkg. Great Lakes lettuce seeds plastic bags	
Have students cut paper towels and place them in the bottom of 4 petri dishes. Moisten the paper towels. (Be sure they have sufficient moisture for 3-4 days, without excess). In two dishes place at least 50 Grand Rapids lettuce seeds, replace lids. In two petri dishes place at least 50 Great Lakes lettuce seeds, replace lids. Place one dish of each kind of seed in a plastic bag and seal them. Put them in a place where light is available. Place the other two dishes in a plastic bag, sealed, in a dark place. After three days check seeds and count how many in each dish have germinated. (Be sure dishes are labeled.)	Why is there a difference in the number of seeds that have germinated in each dish?
Note to teacher: Grand Rapids lettuce seeds need light for germination. Great Lakes do not.	How would the outcomes of this investigation affect seed planting?

Summary Statement: Some seeds need light to germinate.

Reference: Lee, Addison E., Plant Growth and Development, Boston: D.C. Heath and Company, 1963.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: The capture of radiant energy by green things is basic to the maintenance and growth of all living things.

Title: Chlorophyll in photosynthesis

ACTIVITY	QUESTIONS
	What is necessary for a plant to carry on photosynthesis?
Note to teacher: If "sunlight" is the only response, an understanding of the other requirements should be developed.	How can we find out if plants need sunlight and chlorophyll for photosynthesis?
Materials needed for each group: 2 variegated coleus or geranium plants alcohol light source iodine pipette beaker	
Have students observe plants and draw one leaf showing the different colors in the leaf.	Why are areas of the leaf different colors?
Place one plant in darkness and one where it will be exposed to sunlight or other light source. After about four days remove several leaves from the plant that was placed in the dark. Compare the appearance of these leaves with the leaves of the plant left in the sun.	Why are the leaves different in color? (The slight difference in color is due to a reduction in the amount of chlorophyll in the plant kept in darkness.)
Remove the chlorophyll from a leaf of each plant. (Boil leaf in alcohol in water bath.) Test each leaf for starch. Draw the leaves that have been tested and compare them with the first drawing.	

What area of the leaf showed the presence of starch? (The area with chlorophyll)

Why didn't the remainder of the leaf show a positive reaction to the starch test?

Summary Statement: Chlorophyll is needed by plants to change radiant energy to chemical energy.

Auxiliary Words: pigment, chlorophyll

References:

Otto, James H. and Towle, Albert, *Modern Biology*. New York: Holt, Rinehart and Winston, 1965.

Kroeber, Elsbeth, et al., *Biology*. Second Edition. Boston: D. C. Heath and Company, 1965.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: The capture of radiant energy by green plants is basic to the maintenance and growth of all living things.

Title: Phototropism

ACTIVITY	QUESTIONS
Have students place a potted plant by the window. Observe for 2 days.	What happened to the plant by the window? Why did it do this? How is this an advantage to the plant? (helps plant grow) How does it help the plant grow? What is the term scientists give to a plant's response to light?
Optional Activity: Students may investigate the role of auxins in phototropism.	

Summary Statement: Phototropism aids plants in growth.

Concept Term: phototropism

References:

Jacobson, Willard J., et al., *Adventures in Science.* New York: American Book Company, 1959.

Morholt, Evelyn, et al., *A Sourcebook for the Biological Sciences.* New York: Harcourt, Brace and World, 1958.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: Living things are adapted in structure and function to the environment.

Title: Venus's-flytrap

ACTIVITY	QUESTIONS
Obtain a Venus's-flytrap or other insectivorous plant. (Plants may be obtained from Carolina Biological Supply Co., Burlington, N.C.)	
Place the plant in a glass-enclosed terrarium that contains three parts garden loam, one part peet moss and one part sand.	Where are these plants usually found?
Students may need research to answer this question.	Why?
	What are some of the characteristics of their environment? (low in nitrogen)
	What structural adaptation have these plants developed for the capture of nitrogen from their environment?
Allow student to drop Tenebria larvae (meal worms) or small bits of meat into the trap. Observe how the plant reacts when meat was placed in the trap.	How does the plant digest the meat? What does the plant get from the meat? Why does the plant need nitrogen? Where do most plants get their nitrogen?

Summary Statement: Insectivorous plants are structurally adapted to live in a low-nitrogen environment.

Concept Term: legumes

Auxiliary Word: insectivorous

References:

Kroeber, Elsbeth, et al., Biology. Second Edition. Boston: D. C. Heath and Company, 1965.

Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: Living things are adapted in structure and function to their environment.

Title: Mouth structures of insects

ACTIVITY	QUESTIONS
Have students collect insects (grasshoppers, mosquito, fly and butterfly) and place in small vials or glass jars. Observe the insects with hand lens.	How are the mouths of these insects different? What kind of diet do these insects require?
If possible, have students observe the insect eating. Research to find diets of insects.	How are the type of diet and the mouth structure of the insect related? How can a knowledge of the mouth structure of insects assist in pest control? What other structural adaptations can you find in insects that help determine where and how they live?
Students may wish to investigate wings, legs, eyes, etc.	

Summary Statement: The mouth structure of an insect is related to the diet available in its environment.

References:

Fitzpatrick, Frederick L., et al., Living Things. New York: Holt, Rinehart and Winston, 1966.

Jacobson, Willard J., et al., Insects and Senses. New York: American Book Company, 1965.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: Living things are adapted in structure and function to the environment.

Title: Coelenterates VS Arthropods

ACTIVITY	QUESTIONS
Have students give a general description of the river, bay or sea environment. Students should bring to class crabs and jellyfish (living). The number needed will depend on class size and the number of groups with which the teacher has to work.	How are the crab and the jellyfish related? (One relationship is the sharing of the same environment.)
Have students keep the jellyfish and crab in separate containers of salt water (from body of water in which the animals were found) and observe their activities.	Why is the jellyfish so called? How does the jellyfish move about? How does the crab move about?
Have students describe the structure of the crab and the jellyfish.	What are some major differences between the bodies of these two animals? How does their structure help them adapt to their environment?
Have students observe the appendages of each specimen. Name them.	What is the significance of the appendages? What is the difference in the way they function?

Summary Statement: Different structures may be necessary in order for different animals to adapt to the same environment.

Auxiliary Words: appendages, adaptation

Reference: Fitzpatrick, Frederick L., et al., Living Things. New York: Holt, Rinehart and Winston, 1966.

Conceptual Scheme: LIVING THINGS ARE INTERDEPENDENT WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT.

Concept: Living things are adapted by structure and function to their environment.

Title: Structural adaptation of parasites in frogs

ACTIVITY	QUESTIONS
Teachers should have frogs, pithed just prior to class, for pupils to observe and dissect.	What are parasites? How many parasites can you see on these frogs? Where are parasites found? How can we find out if these frogs contain internal parasites?
Students should dissect the frogs, removing the internal organs. Place the internal organs in Ringer's solution or a saline solution. Using teasing needle and scissors, carefully dissect the internal organs and observe the parasites that are present. (Observe parasites with hand lens.)	Where are most of the parasites located? What is the general appearance of the parasites? How do the parasites get their food?
Students may need to do research in order to find answers to this question.	How are they structurally adapted to obtain food? How are the parasites structurally adapted for survival prior to their habitation in the frog? Why don't all organisms contain these same parasites? What do we call an animal containing parasites?

Summary Statement: Parasites can obtain food by particular structural adaptations.

Auxiliary Words: Ringer's solution, parasites, pith, host

References:

Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958.

Witherspoon, James Donald and Hutto, Rebecca, The Living Laboratory. Garden City: Doubleday and Company, Inc., 1960.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: Living things are produced only from other living things.

Title: A look at Spontaneous Generation

ACTIVITY	QUESTIONS
Note to Teacher: This activity will have to be started about fourteen days before you begin this Conceptual Scheme.	How do young mice come into existence? How do fly maggots come into existence? How do frogs come into existence?
Students look up some of the past beliefs that were once held by the proponents of the Theory of Spontaneous Generation.	Can you suggest ways which might test these hypotheses?
After discussion, set up: 1. Place horsehairs in water for worms. 2. Place mud in cool, dark place for frogs. 3. Place rags in warm, dark corner for mice. 4. Set up Redi's experiment involving meat, jars, and flies. (see reference list)	
After 24 hours, examine the jars for blow fly eggs and record where they are found.	On which jars are eggs found?
Leave the jars until maggots appear on the meat in the uncovered jar.	In which jar are maggots found?
Now cover the jar which was originally open and now has maggots with cheese cloth and keep until flies develop. (Life cycle of flies is 13 - 19 days.)	
Review procedure and all data collected.	In which jar did flies develop? Why did no flies and maggots develop in the other two jars?

	167. How did Redi use the results of this experiment to establish the fact that maggots and flies come from other flies and not from decaying meat?
Go back to the mud, horsehair and rags and check for frogs, whip worms and mice.	Have any frogs developed in the mud? Have any mice developed from the rags? Have any worms developed from the horsehair? What is your conclusion as to the correctness of these beliefs?

Summary Statement: The Theory of Spontaneous Generation is not considered true by present-day biologists.

Concept Term: Spontaneous Generation

References: Blanc, San S., Fischer, Abraham S., and Gardner, Olcott, Modern Science--Earth, Space and Environment. New York: Holt, Rinehart and Winston, 1967.

Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. Second Edition. New York: Harcourt, Brace and World, 1966.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: Living things are produced only from other living things.

Title: The alternative to Spontaneous Generation

ACTIVITY	QUESTIONS
Review the previous experiment involving flies and maggots.	Where did the flies come from that developed in the jar with meat?
Note to Teacher: The idea here is to trace these flies back to the eggs which were laid by other flies.	
Show to the students several examples of living things being produced. A suggested list follows: 1. Strawberry plant with runners and new plants 2. Budding hydra 3. Germinating seeds of beans or corn 4. Budding yeast cells (Prepare yeast culture by dissolving corn syrup in water and then adding yeast. After a couple of hours, examine a drop of the yeast culture under the microscope. Staining the cells with 1% neutral red stain will make them more easily visible.)	What do all of these living things that you have just seen have in common? (They are all reproducing.) From what is the young strawberry plant originating? The young hydra? The young yeast? The young corn plant?

Summary Statement: Living things are produced by other living things.

Concept Term: biological reproduction

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: Living things reproduce by different sexual and asexual means.

Title: Reproduction in molds

ACTIVITY	QUESTIONS
	Where have you seen mold growing?
Have several kinds of mold on bread, fruit and other substances. As places where mold can be found are suggested, the teacher may want to show the mold to the students.	What is mold? How did this mold come from this non-living bread? What will happen if we shake this moldy bread over a fresh piece of bread?
Teacher may do this or have students take fresh bread and gently shake the moldy bread over it. Moisten and cover the bread and leave in a warm place. Check the bread after 48 hours.	What happened to the bread? How did this mold get on the bread? What, if anything, was transferred from the moldy bread to the fresh bread?
Students may try making slides of mold culture and detecting what was transferred.	What did you find that could be transferred? What can we call these structures? What other things reproduce by spores?

Summary Statement: Mold is an example of organisms that reproduce by spores.

Concept Term: spores

Reference: Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: Living things reproduce by different sexual and asexual means.

Title: Production of offspring by budding

ACTIVITY	QUESTIONS
	Where are yeast used? What are yeast? How do they reproduce? How could we grow yeast to investigate this?
Set up exercise using small amount of corn syrup in water in a test tube.	What color is the medium?
Have students innoculate the medium with one or two grains of dry yeast. Shake until yeast is dissolved.	What color is the medium now? What caused this color?
Have students make slides of yeast, stain with neutral red and count the approximate number of yeast cells per field of view. Record this number. After two or three days observe again after shaking well.	What difference do you observe in the color? What caused this change?
Have students shake tube and set up slides of yeast, stain with neutral red, count the approximate number of yeast cells.	How did we get this large number of yeast? How did they reproduce? (budding)
Have students try to find yeast that are budding.	What animals reproduce by budding?
Investigate hydra. Make slides of budding hydra.	

Summary Statement: Some organisms reproduce by budding.

Concept Term: budding

Auxiliary Words: yeast, hydra

Reference: Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: Living things reproduce by different sexual and asexual means.

Title: Asexual Reproduction

ACTIVITY	QUESTIONS
Assemble before the students several organisms that are reproducing asexually, e.g., budding hydra, budding yeast, strawberry plant with runners, bread mold, and rooted cuttings.	
Instruct students to observe.	What is one thing that all of these organisms have in common with regard to their method of reproduction? (one parent)
	What do we call the type of reproduction which involves only one parent?
Students should now go to references to answer this question.	What are the different types of asexual reproduction? What are some of the types of living things which reproduce in these ways? What is vegetative reproduction? How has man learned to use asexual reproduction in the propagation of plants?
These are questions which will have to be answered from references.	

Summary Statement: Reproduction which involves only one parent is called asexual reproduction.

Concept Term: asexual reproduction

Auxiliary Terms: budding, spores, grafting, layering, cuttings, runners

Reference: Blanc, Sam S., Fischer, Abraham S., and Gardner, Olcott, Modern Science--Earth, Space, and Environment. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: Living things reproduce by different sexual and asexual means.

Title: Reproduction of fruit flies

ACTIVITY	QUESTIONS
Have available vials of fruit flies that have been set up long enough for all developmental stages to be present. Give vials to students.	What do we call these insects? What are the brown structures on the sides of the vials? What will they develop into?
Carefully remove some of the pupae and place in a vial without media. Let these develop into the adult flies.	What are the worm-like structures in the media? What will they develop into?
Carefully remove some of the media, with larvae, from vials and place in a clean vial.	From what did the larvae develop?
If the answer to this question is not known, students should do library research on this topic.	From where did the egg come? What is the purpose of the egg? What other organisms reproduce by eggs?
Optional Activity: Paper wasp nests may be collected that contain the different developmental stages. Study the different stages to show the wasp reproduces by eggs.	

Summary Statement: Fruit flies are an example of those insects whose life cycle consists of four stages: egg, larva, pupa and adult.

Concept Terms: egg, pupa, larva, adult

References:

Mason, John M. and Peters, Ruth T., *Life Science: A Modern Course*. Princeton: D. Van Nostrand, 1965.

Morholt, Evelyn, et al., *A Sourcebook for the Biological Sciences*. New York: Harcourt, Brace and World, 1958.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: Living things reproduce by different sexual and asexual means.

Title: Sexual Reproduction

ACTIVITY	QUESTIONS
Students are presented with two vials of culture medium, one with fruit flies and the other without fruit flies.	How can we have some young fruit flies produced in the empty culture vial? Why do we need two flies? (After any discussion, teacher should answer -- "because the fruit fly is a sexually reproducing organism." This will probably mean nothing to the students, hence the next question.) What do we mean by sexually reproducing?
The idea might then be conveyed to the students that this might be more easily demonstrated by using a larger sexually reproducing organism, such as a frog, which is larger and easier to see.	
Place a male frog and a female frog before the students. (About the only way to externally sex frogs is to compare the thumbs,--the male's is larger than the female's.)	Compare the two frogs. How are they different structurally? (The students will probably conclude that they are not very different but quite similar.)
Sacrifice the two frogs and dissect to reveal the internal organs.	How are the two frogs different internally?
Remove the eggs from the female and let the students observe.	What do we call these structures? What do we call the sex of an organism which produces eggs? What do we call the organs that produce eggs?

Remove the testes from the male and place in a 50 ml beaker in about 4 ml of water. Cut the testes up and mix thoroughly with the water to make a sperm suspension. In about 5 minutes the sperm will become active. Prepare wet mount slides and let students observe.

These cells are called sperm cells, how are they different from the egg cells? (move, size)
What do we call the sex of an organism which produces sperm cells?
What is the name of the organ that produces sperm cells?
What part do sperm and eggs play in reproduction?

Students should now go to references for the answer to this last question and any of the previous ones which have not been answered.

What is meant by sexual reproduction?
How is sexual reproduction different from asexual?
What are gametes?
What is fertilization?
What is a fertilized egg?

Summary Statement: Many living things reproduce sexually -- i.e., a sperm cell must unite with an egg cell to produce a new individual.

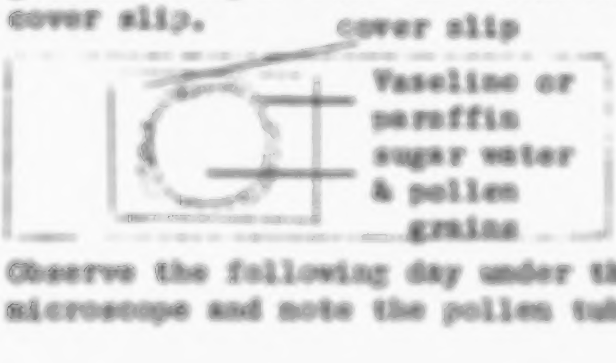
Concept Terms: sexual reproduction, gametes, sperm, eggs, fertilized egg, fertilization, ovaries, testes

Reference: Blanc, Sam S., Fischer, Abraham S., and Gardner, Olcott, Modern Science--Earth, Space and Environment. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: Living things reproduce by different sexual and asexual means.

Title: Reproduction in flowering plants

ACTIVITY	QUESTIONS
	What are flowers? What is the purpose of flowers? How do they produce seed?
Have large flowers (petunia, lily, daffodil, etc.) available for students to dissect.	What are these? What is their purpose?
Dissect flowers, removing and keeping all parts. Have charts available for the students to use in identifying parts of the flower.	What is the structure in the center of the flower?
Bisect a pistil longitudinally.	What is located at the base of the pistil?
Make a cross-section cut of the base of the pistil (ovary). Direct students to look for ovules.	What are the structures in the ovary? What are specialized sex cells of this type called? What is needed for this gamete to become a complete new plant?
Direct students to find stamens.	What do the stamens produce?
Make slides of pollen grains.	What does pollen look like? What is inside the pollen grains? What will the pollen grain develop into?
Germinate the pollen grains. Set up a Vaseline or paraffin slide with sugar water in the center. Place pollen grains in sugar water and cover with cover slip.  cover slip Vaseline or paraffin sugar water & pollen grains	
Observe the following day under the microscope and note the pollen tubes.	What is the purpose of the pollen tube?

Do library research on pollination and the function of pollen tubes. Students may disect seeds that have been germinating for one or two days to see the young embryo inside.	What results when the male (from stamen) and female (from ovary) gametes unite? What will this produce?

Summary Statement: Flowering plants produce male and female gametes that unite to form a new plant.

Concept Terms: ovary, gametes, stamens, pistil, pollen grains, pollen tube.

Reference: Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958.

Conceptual Scheme: A LIVING THING IS A PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: A living thing reproduces itself and develops in a given environment.

Title: Guppies in salt water

ACTIVITY	QUESTIONS
Have guppies in class for observation. Students should keep a careful record of the number of offspring and gestation time in order to establish the rate of reproduction of guppies.	What life functions must these fish carry on so that the species will survive? What environmental conditions are necessary for guppies to survive? (fresh water, etc.) What would happen if salt were added to the water?
Set up two aquaria with plants and with the same number of guppies in each. Keep all factors of the environments the same except to add to one tank two tablespoons of salt per gallon of water. Observe the guppies in the control tank and in the tank containing salt for several weeks. Count the number of fish in both tanks at the end of several weeks.	What happened to the rate of reproduction for the guppies in each tank? Why? What are some other environmental factors that affect reproduction of organisms?

Summary Statement: Some organisms will reproduce and develop only in a given environment.

Conceptual Scheme: A LIVING THING IS A PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: A living thing reproduces itself and develops in a given environment.

Title: Development of frog eggs

ACTIVITY	QUESTIONS
	How do frogs reproduce? Where are frog eggs usually found? What conditions are necessary for frogs' eggs to develop? How can we investigate this?
Have students collect frog eggs and place them in six separate containers. There should be approximately 150 eggs in each container. Three containers should contain pond water and three should contain sea water (or Saline solution). Place one container of each in a 5°C environment, one of each in 12°C, one of each in a 25°C environment. Observe 5 or 10 eggs daily with hand lens or microscope. Discard after observation. Note: Make a graph showing the rate of development in the frog eggs.	What changes in the eggs were observed in the different environments? What was the length of time required for the development of the eggs in each environment? Which of these environments seems to be most suitable for the development of frog eggs? How is the development of other organisms affected by their environment?

Summary Statement: Environmental factors affect the development of frogs eggs.

References:

Fitzpatrick, Frederick L., et al., Living Things. New York: Holt, Rinehart and Winston, 1966.

Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1966.

Conceptual Scheme: A LIVING THING IS A PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: A living thing reproduces itself and develops in a given environment.

Title: The effects of light on reproduction (flowering) of morning-glory (variety Scarlett O'Hara)

ACTIVITY	QUESTIONS

Materials:
1. morning-glory seed (variety Scarlett O'Hara)
2. sterilized soil
3. a dark chamber
4. a light chamber equipped with at least two 40-watt fluorescent lamps (cool white)

Procedure:
1. Grow seeds in sterilized soil under fluorescent light. Expose to at least 18 hours of light per day until large enough to use. They are ready to use as soon as the cotyledons have expanded.
2. When the plants are large enough to use, divide them into lots A and B.
3. Both lots of plants should be put in the light chamber. Lot A should only receive 8 - 10 hours of light daily. At the end of this time period, they should be removed to the dark chamber. Lot B must be left under the fluorescent lamps for 10 more hours (if you have an electric time switch) daily, or left under the light all of the time.
4. The next morning put lot A back under the light for 8 - 10 hours, etc. Continue these daily treatments until flower buds are obvious.

5. Observations:
   Record
   a) data of planting
   b) date treatment began
   c) length of the light and dark periods
   d) how many short days were required to induce flower-bud formation.

Notes to teacher:

1. Soil may be sterilized by placing small lots of moist soil in a shallow pan and baking for at least 1 hour at 215° F; let cool but do not use for two weeks.
2. Plants are usually grown in clay pots of 3, 3½, or 4 inch diameter but other containers may be substituted.
3. Plants in lot A should be the only ones to flower as this variety of morning-glory is a short day plant -- i.e., it flowers only when days are short and nights are long.
4. Start this activity (planting the seed) 10 weeks before the results are needed.
5. The dark chamber can simply be a cabinet which will completely exclude light.
6. The light chamber can be a shelf with the fluorescent lamps suspended over them.

When flowers are obvious, review the procedure with the students and allow them to observe the two lots of plants.

How were the plants in lots A and B treated differently?
What is the variable in this experiment?
How are the two groups of plants different?
To what can we attribute the flowering of the plants in lot A but not in lot B?

Summary Statement: The reproduction (flowering) of some plants, e.g., Scarlett O'Hara variety of morning-glory, is affected by the length of day.

Reference: United States Department of Agriculture, Agricultural Research Service, Special Report, Plant Light--Growth Discoveries: From Photoperiodism to Phytochrome, 1961.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The cell is the unit of structure and function; a living thing develops from a single cell.

Title: **Living things have a cellular structure**

ACTIVITY	QUESTIONS
Note to teacher: The idea and purpose behind this exercise is to allow the students to observe a variety of living material and note the cellular structure of all of it. Materials: onions, toothpicks (flat), frogs (living), filamentous algae, leaves (lilac, lettuce, or bryophyllum), iodine or methylene blue stain, microscope slides, coverslips, monocular microscope, medicine dropper Observe each of these living materials under the microscope by preparing wet mount slides of them (*see reference list at end of activity). Instruct the students to draw "rough sketches" of what they see under low power (100x). 1. Onion epidermis 2. Cheek cells (epithelial cells) 3. Blood cells (frog) - Kill a frog and obtain a few drops of blood and dilute in a small quantity of water. Stain with methylene blue stain. 4. Filamentous algae 5. Epidermis leaf cells - Tear a leaf at a right angle to the main vein. Then with a forceps pull off strips of the thin membrace which is the lower epidermis and mount in water. Stain with iodine. With the drawings in front of the students, discuss.	

183. How is the microscopic appearance of each of these different living materials similar? (They all have a cellular structure.)

Summary Statement: Living things are composed of small structural units called cells.

Concept Term: cell

Auxiliary Terms: stain or dye, epidermis, epithelial

Reference: Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. Second Edition. New York: Harcourt, Brace and World, 1966.

__Conceptual Scheme:__ A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

__Concept:__ The cell is the unit of structure and function; a living thing develops from a single cell.

__Title:__ The similarities and differences of living cells

ACTIVITY	QUESTIONS
Draw or have drawn on the chalk board a large cell of each of the types of cells they observed in the previous exercise. They should be detailed enough to show the nucleus, cell wall, cell membrane, cytoplasm, and chloroplasts (where applicable), but these parts should not be labeled as such.	
Ask the students to name each type of cell by looking at their labeled drawings from the previous exercise.	How are these cells different? (size, shape) How are these different cells similar?
__Note to Teacher:__ Try to get the students to recognize that these cells have certain similarities: same basic structural plan with nucleus, cytoplasm, cell wall, cell membrane, chloroplasts (in green plant cells). Students should do research to identify and label these structures on the drawings on the chalk board.	
Differentiate between the cell wall and cell membrane.	
Have students examine under microscopes slides of onion skin and lower leaf epidermis. Students should make a large drawing of one cell of each type and label the parts they can see.	

__Summary Statement:__ All living cells, though not exactly alike, have many similar parts.

__Concept Terms:__ cell wall, cell membrane, cytoplasm, nucleus, chloroplast

Auxiliary Term: cell

References:

Blanc, Sam S., Fischer, Abraham S., and Gardner, Olcott, Modern Science--Earth, Space, and Environment. New York: Holt, Rinehart and Winston, 1967.

Fitzpatrick, Frederick L., Modern Life Science. New York: Holt, Rinehart and Winston, 1966.

Mason, John M. and Peters, Ruth T., Life Science: A Modern Course. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The cell is the unit of structure and function; a living thing develops from a single cell.

Title: Cells are the basic functional units of living things (Part I)

ACTIVITY	QUESTIONS
Materials: rich culture of paramecium (species - Paramecium Candatun), methyl cellulose solution for slowing paramecium, glass slides, cover glasses, raw cotton fibers, microscopes, prepared slides of paramecium in fission	
	What are some things that living things do that non-living ones do not? (movement, reproduction, use oxygen, get and use food, sensitive to and respond to the environment, get rid of waste products produced by chemical processes within them)
Teacher should list these life functions on the board.	What do you think is the smallest part of a living thing that can perform these functions?
Investigate a one-celled organism (paramecium).	
Make a ring of methyl cellulose on a glass slide and place a couple of drops of paramecium culture in the center of the ring. Add a few scattered raw cotton fibers and cover with coverslip. Observe under low power.	
	How many cells is each paramecium composed of? What do you observe the paramecia doing? (moving) Is there any evidence that the paramecia are aware of their environment and can react to it? (When they come in contact with the cotton fibers)

Note to Teacher: Sometimes in rich cultures of paramecia it will be possible to find some dividing (fission). Instruct the students to look for this. If none are found, let students observe prepared microscopic slides of paramecium undergoing fission.

There should now be an activity to sum up the life functions that have been observed in the paramecium.

What do you observe these paramecia doing? (dividing)
How many paramecia will there be from each one that is dividing?
What can we say the paramecia are doing? (reproducing)

Which of the life functions listed on the board did you observe the paramecia doing? (movement, awareness to and reacting to its environment, reproduction)
What is your answer to the question: "What is the smallest part of a living thing that can perform the life processes?"

Summary Statement: The single-celled paramecium can be observed to perform many of the life functions.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The cell is the unit of structure and function; a living thing develops from a single cell.

Title: Cells are the basic functional units of living things (Part II)

ACTIVITY	QUESTIONS
Note to Teacher: This activity must be set up one day ahead of time.	
Review previous activity by asking. . .	Are there any life processes which we identified and listed on the board that we did not observe in the paramecium? If so, which ones? Does this necessarily mean that the paramecium cannot perform these functions? Explain.
The point might be made that to observe the other life functions in paramecia requires considerably more skill and technique. The other life functions by a single cell can be observed being performed indirectly with yeast.	
Set up two containers with water/corn syrup solution. To one add dried yeast culture, do not add yeast to the other container. One day later compare the two containers.	What differences do you observe in the contents of the two containers? (CO_2 bubbles, smell of alcohol, and cloudy appearance in the container with yeast) How would the contents of the two containers appear under the microscope? (Observation will of course reveal yeast cells in one, but not the other.) What are these one-celled organisms called?

Instruct the students to look up "yeast" and "fermentation" to find the answers to the following questions. . .

What are the bubbles that were observed in the yeast culture?
Where did they come from?
What is the odor observed in the yeast culture?
Where did it come from?
What served as food for the yeast?

What life functions have been observed being performed by yeast? (getting and using food, getting rid of wastes)

Summary Statement: One celled paramecia and one celled yeast can perform the basic functions of life.

Concept Terms: excretion, fermentation, food getting

References: Blanc, Sam S., Fischer, Abraham, and Gardner, Olcott, *Modern Science--Earth, Space, and Environment*. New York: Holt, Rinehart and Winston, 1967.

Mason, John M. and Peters, Ruth T., *Life Science: A Modern Course*. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The cell is the unit of structure and function; a living thing develops from a single cell.

Title: Cell specialization in multicellular organisms

ACTIVITY	QUESTIONS
	How are you different from a paramecium? (You will get many answers, but lead up to the fact that a paramecium consists of only one cell, while a human is composed of many cells.)
	How could we determine whether all of the cells found in a multicellular organism (like man) are alike?
Have students observe prepared slides of various human tissues to get an idea of the different types of cells that the human is composed of.	What are the major kinds of cells found in man?
	Why do you suppose the cells are different? What is the specialized job that each type cell does?
Students do library research on the functions of various types of human cells.	

Summary Statement: In a multicellular organism (as man), the work of the body is accomplished by the combined work of many individual cells, each doing some specialized job.

Auxiliary Term: multicellular

References:

Mason, John M. and Peters, Ruth T., Life Science : A Modern Course. Princeton: D. Van Nostrand, 1965.

Fitzpatrick, Frederick L., Modern Life Science. New York: Holt, Rinehart and Winston, 1966.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The cell is the unit of structure and function; a living thing develops from a single cell.

Title: From one cell

ACTIVITY	QUESTIONS
Two days prior to this exercise, students should place brine shrimp eggs in water. Give each group of students a culture dish with one inch of salt water (3-4 grams NaCl/liter) and brine shrimp eggs. Do not tell them what the brine shrimp eggs are or what they may expect to happen - simply ask them to observe them.	We have seen that one-celled organisms reproduce by dividing. When a multicellular organism reproduces could it simply split in two? How, then, do multicellular organisms reproduce?
After discussion, have students observe with magnifying glasses or binocular microscopes the salt water with brine shrimp set up two days earlier.	What do you observe in the culture dishes? Where did these brine shrimp larvae come from? Do you observe any evidence that they developed from the "items" we put in the salt water two days ago? (empty egg casings floating on water) What do we call the structures from which the brine shrimp developed?
Note to Teacher: The answer to this question will probably be "eggs." At this time, review the concept of "fertilized egg" or "zygote".	What is meant by a fertilized egg? How are fertilized eggs formed?
Have students do research on gametes, fertilization, zygotes, etc.	

Summary Statement: Sexually produced organisms develop from a single cell (zygote).

Concept Terms: gamete, fertilization, zygote

References: Fitzpatrick, Frederick L., Modern Life Science. New York: Holt, Rinehart, and Winston, 1966.

Mason, John M. and Peters, Ruth T., Life Science : A Modern Course. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The cell is the unit of structure and function; a living thing develops from a single cell.

Title: The frog

ACTIVITY	QUESTIONS
Show filmstrip "Frog Anatomy -- Life Cycle," available from Loveville Educational Center. This filmstrip (with accompanying taped narrative) presents the life cycle of the frog. Some parts are rather detailed and advanced. It is suggested that the taped narrative not be used at this grade level, but that the teacher preview and use those frames that are suitable for the students.	What does a frog start out as? (zygote) What happens to this zygote as development begins and proceeds? What is the developing frog called in the early stages of development? (embryo) By what processes does the embryo develop into a new frog? (cell division and differentiation)

Summary Statement: The fertilized egg develops into a new individual by the processes of cell division and cell differentiation.

Concept Terms: embryo, cell differentiation, cell division

Auxiliary Terms: gametes, zygote, fertilization

Reference: Filmstrip, Frog Anatomy -- Life Cycle. Carolina Biological Supply Company.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The characteristics of a living thing are laid down in a genetic code.

Title: Acquired and inherited traits

ACTIVITY	QUESTIONS
	How are people different?
List these differences on the chalk board.	What do we call these differences? (traits) What causes these traits? (Some are inherited and some are acquired.)
Students may need to do research to find the causes of traits.	Which of the traits we have listed are inherited?
Note: Students may know whether some traits are inherited or acquired but may need to investigate others. Make separate lists of acquired and inherited traits.	

Summary Statement: Some traits are acquired and some are inherited.

Concept Term: trait

Auxiliary Words: acquired, inherited

References:

Hutchins, Carleen Maley, Life's Key - DNA. New York: Coward-McCann, Inc., 1961.

Brandwein, Paul F., et al., The World of Living Things. New York: Harcourt, Brace and World, 1964.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The characteristics of a living thing are laid down in a genetic code.

Title: Location of chromosomes in living things

ACTIVITY	QUESTIONS
	What is responsible for the inherited traits an organism possesses? (chromosomes) Where in the body are chromosomes found?
Have students locate chromosomes in prepared slides of salivary glands of Drosophila larvae, onion root tip, whitefish eggs, starfish or worms.	Where in the cells did you find the chromosomes? How many chromosomes are in one cell of a living thing?
Do research on the number of chromosomes a living thing contains. Find the chromosome numbers of a variety of organisms.	What did you learn about the number of chromosomes contained in one cell of an organism? What is the chromosome number of the fruit fly?

Summary Statement: Chromosomes are found in the cells of organisms. They exist in pairs and the number is specific to the species.

Reference: Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. Second Edition. New York: Harcourt, Brace and World, 1966.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The characteristics of a living thing are laid down in a genetic code.

Title: Reducing the number of chromosomes

ACTIVITY	QUESTIONS
	How are inherited traits passed from parent to offspring? What is the only physical link between parent and offspring? What in the gamete is responsible for carrying the trait from the parent to offspring? (chromosomes) How much genetic material is passed on by the male? How much genetic material is passed on by the female?
Have students draw circles to represent cells. One for each parent and one for the new individual. Select an organism, preferably Drosophila, from the previous exercise of which the chromosome number is known. Use short pieces of pipe cleaners or other similar objects to represent the chromosomes. A different color for each pair of chromosomes should be used. Have the students combine the chromosomes from the parents to represent a new individual.	How many chromosomes does your new individual have? What is wrong genetically? How can this be corrected?
Have students discuss their own ideas of how this can be corrected. If no solution is found have them do research on meiosis.	What is the reduction of the chromosome number called? What will the new individual resemble?

Summary Statement: Reduction division or meiosis reduces the number of chromosomes in the gametes.

Concept Term: meiosis

Reference: Mason, John M. and Peters, Ruth T., Life Science: A Modern Course. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The characteristics of a living thing are laid down in a genetic code.

Title: Gregor Mendel

ACTIVITY	QUESTIONS
	How many chromosomes do Drosophila have? How many traits do Drosophila have? If it is true that chromosomes control traits what must be true about the number of traits each chromosome controls? What must be true of the structure of chromosomes to allow a single chromosome pair to control many traits.
Have students do research on Gregor Mendel to get the history of genetics and information that will be needed in the following exercises. The following list of items are things they may find in their research: 1. genes 2. meiosis 3. fertilization 4. dominant 5. recessive 6. alleles 7. homozygous 8. heterozygous 9. hybrids 10. monohybrids 11. dehybrids 12. genotype 13. phenotype	Adapt questions to the class and to the type of research the teacher has them do.

Summary Statement: Hereditary traits are controlled by genes.

Concept Term: genes

Reference: Mason, John M. and Peters, Ruth T., *Life Science: A Modern Course*. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The characteristics of a living thing are laid down in a genetic code.

Title: Dominant and recessive traits

<table>
<tr><th>ACTIVITY</th><th>QUESTIONS</th></tr>
<tr><td>Have students attempt to roll their tongues.</td><td>How many tongue rollers do we have?
How many non-rollers?
What is this? (a trait)
What determines traits?</td></tr>
<tr><td>Discuss several traits that can be checked in class. Gather data on tongue-rolling trait. Record the data on a chart.
Illustration:<table><tr><th></th><th>Number in class</th><th>Percent in class</th></tr><tr><td>Tongue Roller</td><td></td><td></td></tr><tr><td>Non-roller</td><td></td><td></td></tr></table></td><td>What is the percent of rollers?
What is the percent of non-rollers?
Which trait is dominant?
How can we find out?</td></tr>
<tr><td>HEREDITY DATA
Have students determine the number of tongue rollers and non-rollers in their immediate families (parents, brothers and sisters) and record the data. Construct a chart to record the data for all of the families.</td><td>How do the family percentages compare to the class percentages?
Which trait is recessive?</td></tr>
<tr><td>Note to Teacher: Students may need research to determine which is dominant and which is recessive. (If tongue rolling is dominant, a marriage of two tongue rollers may or may not produce children who can not roll their tongues. If tongue rolling is recessive, a marriage of two tongue rollers produces only tongue roller children.) The way to determine which trait is dominant is more important is more important than which is dominant.</td><td></td></tr>
</table>

Optional Activity: Students may want to discuss and do research on hereditary diseases such as hemophilia, diabetes mellitus, and allergies.

How did you determine which is recessive?
How is a knowledge of genetics useful to man?

Summary Statement: Humans have dominant and recessive traits.

Auxiliary Words: dominant, recessive

References:

Brandwein, Paul F., et al., The World of Living Things. New York: Harcourt, Brace and World, 1964.

Fitzpatrick, Frederick L., et al., Living Things. New York: Holt, Rinehart and Winston, 1966.

Otto, James H. and Towle, Albert, Modern Biology. New York: Holt, Rinehart and Winston, 1965.

Pfeiffer, John and the Editors of "Life", The Cell. New York: Time Inc., 1964.

Smith, Ella Thea, Exploring Biology. Fourth Edition. New York: Harcourt, Brace and World, 1954.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The characteristics of a living thing are laid down in a genetic code.

Title: Dominant and recessive traits in corn

ACTIVITY	QUESTIONS
Give students ears of genetic corn, ratio purple to yellow 3:1.	How many colors of corn are there? How many purple grains are there? How many yellow grains are there? How many more purple grains than yellow grains are there? Which color do you think is dominant? Which do you think is recessive?
If the answer to this question is not known, have students refer back to the research they did on Mendel.	What type of genes must the white seeds have if they are recessive? What type of genes can the purple seeds have? What type of genes must the parents of these seeds have had?
Let students investigate ways to figure this out.	

Summary Statement: Dominant and recessive traits are determined by pairs of genes.

Concept Terms: dominant and recessive

References:

Blanc, Sam S., Fischer, Abraham S., Gardner, Olcott, Modern Science I. New York: Holt, Rinehart and Winston, 1963.

Mason, John M. and Peters, Ruth T., Life Science: A Modern Course. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The characteristics of a living thing are laid down in a genetic code.

Title: The DNA molecule

ACTIVITY	QUESTIONS
The teacher will prepare two sets of seven boxes each. The seven boxes in each set will be labeled as follows: 1. seed shape 2. seed color 3. seed coat color 4. pod shape 5. pod color 6. flower position 7. stem length These boxes represent the seven traits Mendel studied in garden peas. In this activity we are going to "cross" two pea plants, each of which is hererozygous for each of these traits. Prior to class the teacher will prepare magnetic recording tape in the following manner. He will record the "genes" for each trait, such as, for seed shape he would say round seeds, wrinkled seeds, for seed color he would say yellow seeds, green seeds, etc. Having done this for each of the seven traits, cut the tape in segments and place in the proper boxes. Example - the box marked "seed shape" would have one piece of tape recorded on it "round seeds" and one with "wrinkled seeds," etc. It is recommended as the tape is being recorded, after each statement the recorder should be stopped and the tape marked so the teacher will know where to cut the tape. The teacher will prepare two of the above sets of tape, one for each set of boxes. One set of boxes with tape "genes" will represent one pea plant which is to be crossed with another pea plant represented by the second set of boxes.	

At the beginning of class students will be told they are going to make a pea plant by "crossing" two pea plants, each of which is heterozygous for the traits listed previously.
Students will then be told about the two sets of boxes and what they represent. The instructions for making the pea plant will be obtained by choosing one piece of tape from the box marked "seed shape" from one of the sets and splicing it to one piece of tape from the box marked "seed shape" in the other set. Repeat this procedure for each of the six boxes in each set. Therefore, you will end up with a tape made by splicing fourteen (14) pieces of tape together. When this is played back, instructions for each trait will be obtained. By knowing which is dominant and recessive it will be easy to ascertain the appearance of the new pea plant.

Do research on composition and structure of the DNA molecule. Using "tinker toys" or other educational building materials build a simple model of the DNA molecule.

Where did we get our information for our pea plant?
Where does a living thing obtain the instructions for its genetic traits?
What in the cell is the tape like?
What makes up the chromosome?
What makes up genes? (deoxyribonucleic acid (DNA))
What is DNA? (molecule)
What are the six basic substances DNA is composed of?
How are these substances arranged in the DNA molecule?

What compounds are the spirals composed of?
What materials compose the cross links of the ladder?
What is the length of the DNA molecule?
How could this molecule control the activity of the body?
Why is the DNA molecule said to contain the "Code of Life".

Summary Statement: DNA contains the "Code of Life" that determines the traits of that organism.

Concept Term: DNA

References: Hutchins, Carleen Maley, *Life's Key - DNA*, New York: Coward-McCann, Inc., 1961.

Pfeiffer, John and the Editors of "Life", *The Cell*, New York: Time, Inc., 1964.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The expression of hereditary traits is influenced by the environment.

Title: Environmental influence on expression of heredity traits

ACTIVITY	QUESTIONS
Hold up potatoes for observation.	What effect would the environment have on the expression of inherited characteristics of these potatoes? How could we find out?
Have students cut a potato in half and plant the halves in separate containers of soil. Water enough to keep the soil moist. Place one in a cool, lighted area and one in a cool, dark area. Observe until plant shoots are 5 - 6 inches high.	What differences do you observe in the plants? Why is there a difference when both plants have the same genetic material or code? What is the relationship between the inherited characteristics of a plant and the environment in which it develops?
Note: Two onion or narcissus bulbs may be used to observe the effect of environmental conditions on expression of plant inheritance.	

Summary Statement: Some inherited characteristics of the potato plant are modified by the environment.

References:

Brandwein, Paul F., et al., *The World of Living Things.* New York: Harcourt, Brace and World, 1964.

Kroeber, Elsbeth, et al., *Biology.* Second Edition. Boston: D. C. Heath and Company, 1965.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The expression of hereditary traits is influenced by the environment.

Title: Food and growth

ACTIVITY	QUESTIONS
Note to Teacher: Obtain two animals (litter mates, if possible) four to six weeks prior to the activity. (White rats may be obtained from the Maryland Society for Medical Research, 522 West Lombard Street, Baltimore, Maryland.) Feed one of the animals with a balanced diet and the other with a protein deficient diet. During the time prior to the activity weigh the animals twice weekly and keep a record of the weights. This can be done by students. Students should understand that these animals are litter mates, of the same sex, and have very much the same genetic background.	What differences do you observe between these animals? What may have caused these differences? How could we determine whether or not the environment was responsible for these differences?
Reverse the diets of the rats and continue to weigh until a change is noticed.	

Summary Statement: Food is an environmental factor that affects growth.

References:

Turtox Service, White Rats Leaflet. Number 40. Chicago: General Biological Supply House.

Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. Second Edition. New York: Harcourt, Brace and World, 1966.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The expression of hereditary traits is influenced by the environment.

Title: Production of pigment in coleus plants

ACTIVITY	QUESTIONS
	How could we get coleus plants that are genetically alike?
By using cuttings from the same plant establish several potted red coleus plants.	What kind of reproduction is this? What are some hereditary traits of these plants? (amont those mentioned include color) What is responsible for color? (pigment) How does the amount of light a plant receives affect its ability to produce pigment? How could we find out?
Place one plant in dark condition, one with very little light, one with moderate light and one with bright light. Observe after one week.	How do we know these plants are genetically alike? What hereditary trait is investigated in this exercise? What differences do you observe in the amount of pigment in these plants? What is the variable in this experiment? What caused the differences in the amount of pigment produced by each plant? Was the cause environmental or hereditary? What seems to be the major factor in determining the amount of pigment in coleus plants?
Note to Teacher: The point should be made, it can not be said which is more important, but that environment and heredity together determine the development of hereditary traits.	

Summary Statement: Environment influences the production of pigment in coleus plants.

Concept Term: pigment

Reference: Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. Second Edition. New York: Harcourt, Brace and World, 1966.

Conceptual Scheme: A LIVING THING IS THE PRODUCT OF ITS HEREDITY AND ENVIRONMENT.

Concept: The expression of hereditary traits is influenced by the environment.

Title: Influence of temperature on wing length of Drosophila

ACTIVITY	QUESTIONS
Have vertigal wing Drosophila for students to observe. Observe the different traits with a hand lens. Record observations.	How might temperature affect the development of offspring from these flies? How could we find out?
Set up two cultures of these flies for each group of students. Place one culture in incubator at a temperature of 88° F. Maintain the other culture at room temperature. Observe after offspring have developed (about two weeks).	What differences do you observe between the flies in the two cultures? How were the environments of these two groups of flies different? What environmental factor may have caused this difference in wing length?

Summary Statement: Environment may influence the expression of wing length of Drosophila.

Reference: Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. Second Edition. New York: Harcourt, Brace and World, 1966.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: There are different forms of living things.

Title: Different forms of animals

ACTIVITY	QUESTIONS
Assemble as many different animals (living and preserved specimens) as possible. Place these at stations around the room. Allow the students to go around the room and observe each kind in an orderly sequence.	After looking at all of these animals, what are some general observations that you made?
Note to Teacher: The answers that you get to a question like this will be varied, but eventually the point should be made that these animals are different.	In what ways are these animals different from each other? What did you observe that might indicate that some animals are more closely related than others?

Summary Statement: There are different forms of animal life on earth today.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: There are different forms of living things.

Title: Different forms of plants

ACTIVITY	QUESTIONS
Repeat the previous exercise, this time using as many different kinds of plants as possible. A suggested list follows: mosses pine flowering plants "running cedar" "crow's-foot" algae ferns	

Summary Statement: There are different forms of plants on earth today.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: There are extinct forms of living things.

Title: The fossil evidence

ACTIVITY	QUESTIONS
Show students a picture of some extinct species - e.g., passenger pigeon, dodo bird, dinosaur, etc.	What is the name of this animal? Are there any on earth today?
You may have to tell students what the animal is and have them quickly look up the answer to this question.	If there are no members of a type of living thing remaining on earth, we say that this form is ______? (extinct)
Show the film, The Fossil Story.	How do we know that there are many extinct forms of living things? (fossils)

Summary Statement: There are extinct forms of living things as revealed by fossils.

Concept Terms: extinct, fossils

Reference: Film, The Fossil Story. Shell Oil Company, Film Library, 149-07 Northern Boulevard, Flushing, New York 11354. (Running time is 19 minutes.) Order 4 - 6 weeks in advance.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: There are extinct forms of living things.

Title: Fossils found locally

ACTIVITY	QUESTIONS
Note to Teacher: Prior to doing this activity, secure the references listed at the end of this activity. Also, inquire among your students if they have fossils and ask them to bring them in.	Are the fossils of any extinct forms of living things found locally?
Show students local fossils you have in your school.	What kind of living things were they? How old are these fossils?
Have students go to references for the answers to these questions.	How do we know that these fossil forms are extinct?
Note to Teacher: A field trip could be planned to the fossil deposit at Scientists' Cliffs, Calvert County, Maryland. For information contact the Marine Biological Laboratory at Solomon's, Maryland. Some students may know of a small local deposit that could also be visited.	

Summary Statement: The local fossil record reveals the existence of extinct forms of life.

Auxiliary Term: fossil

References:

Miocene Fossils of Maryland, Bulletin Number 20. State of Maryland, Department of Geology, Mines and Water Resources. Baltimore: Waverly Press, 1957. ($1.00 per copy)

Clark, W. B., et al., Eocene. Systematic Reports, Maryland Geological Survey, State of Maryland, Department of Geology, Mines and Water Resources. Baltimore: The Johns Hopkins Press, 1901, reprinted 1963. ($2.50 per copy)

(The above references may be purchased from the Department of Geology, Mines and Water Resources, Johns Hopkins University, Baltimore, Maryland 21218. They could probably be borrowed from Enoch Pratt Library through your local library.)

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: There are extinct forms of living things.

Title: Modern extinction

ACTIVITY	QUESTIONS
Note to Teacher: The purpose of this activity is to direct the students' attention to animal forms which have become or are in danger of becoming extinct in modern times - e.g., Carolina paroquet, European lynx, passenger pigeon, dodo, whooping crane. Choose those species on which information can be found.	When did these animals become extinct? What was the cause of their extinction? Was man a factor? How many whooping cranes are in the world today? What are biologists doing to preserve this species?
Note to Teacher: The whooping crane has been in the news a great deal lately. Eggs were collected by U.S. and Canadian biologists and hatched at Patuxent Wildlife Refuge, Laurel, Maryland. The Reader's Guide to Periodical Literature would probably lead you to recent articles on this subject.	

Summary Statement: The extinction of animal species continues in modern times.

Reference: Film, The Whooping Crane. 1958, 16 mm sound, 14 minutes. (Order one month in advance from Bureau of Sport Fisheries and Wildlife, 800 Peachtree, 7th Building, Atlanta, Georgia 30323.)

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE

Concept: There are extinct forms of living things.

Title: A trip to the National Museum of Natural History.

ACTIVITY	
Note to Teacher: What better way of summarizing this concept than by taking the students to the Museum of Natural History at the Smithsonian, Washington, D.C. Students should go to the museum with instructions to look for specific things, among others are: archaeopteryx, evolution of the horse, extinct animal forms, plant fossils. While there you should inquire about any free materials that might be obtained which can be used in the classroom.	

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Living things can be classified according to structure.

Title: We group things

ACTIVITY	QUESTIONS
Provide for each group of students a tray that contains a variety of laboratory equipment, such as test tube, graduate, rubber stoppers, rubber tubing, test tube, clamp, wire, ring from ring stand, beaker, flask, etc. Have students sort items into groups.	What was the basis for your grouping system? How could the objects be regrouped?
Have students regroup the items.	What was the basis for your grouping this time?
Give the students an additional item and have them place it in one of their groups if possible.	What must you do to be able to add new items to your group?
Have students regroup so new items may be added. Have students group items again - then exchange places with another team. Have students attempt to determine the basis for the grouping.	Why is it important for other people to be able to use the system you set up? How could a grouping system help biologists to identify and study the living things on earth?

Summary Statement: Objects can be grouped according to their similarities.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Living things can be classified according to structure.

Title: **Grouping living things**

ACTIVITY	QUESTIONS
Note to Teacher: Refer to Curriculum Science Guide, Volume II, for review of classification.	
Have available a number of different kinds of animals (earthworm, turtle, frog, protozoa culture) and plants (algae, mosses, seed plants). Place these in random order on the desk.	What do all these organisms have in common? How could we group these living things?
Students may separate the animals from the plants.	How could we group the animals? How could we group the plants?
Students may suggest grouping them according to size, shape, color, and habitat.	
Have students group the living things according to their suggestions and record the basis for their grouping.	What other ways could we group these plants and animals? How do biologists group living things?
Direct students to references that explain biological classification.	What advantages does the system of classification used by biologists have over your system of classification? What do we call scientists who classify living things? What is the science of classification called? Why is the science of taxonomy important?
Have students do research on taxonomists, such as Linnaeus, Buffon, Cuvier, and Aristotle.	

Summary Statement: Living things can be classified according to similarities and differences in structure.

Concept Term: taxonomy

References:

Brandwein, Paul F., The World of Living Things. New York: Harcourt, Brace and World, 1965.

Fitzpatrick, Frederick L., et al., Modern Life Science. New York: Holt, Rinehart and Winston, 1966.

Mason, John M. and Peters, Ruth T., Life Science: A Modern Course. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Living things can be classified according to structure.

Title: Grouping plants

ACTIVITY	QUESTIONS
Have on hand a large number of flowers along with a leaf from the plant if possible. Include both dicotyledons and monocotyledons, and branches, with cones, from several gymnosperms. (Old flowers can usually be obtained from florists in the area.)	What do these flowers have in common? What basis for grouping plants do biologists use? How could we group these plants?
Have students do research to find characteristics of the major phyla of the plant kingdom. Using these characteristics, have the students try to place the plants in their proper groups.	What differences separate the cone bearing plants from the other plants? How did you subdivide the other plants? How are these divisions helpful to biologists?

Summary Statement: Plants can be grouped according to structure.

Reference: Mason, John M. and Peters, Ruth T., *Life Science: A Modern Course*. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Living things can be classified according to structure.

Title: Animals can be classified according to their structure

ACTIVITY	QUESTIONS
Have available specimens of the phylum Arthropoda (crayfish, spider, insect, millepede, centipede) and animals of other phyla (frog, turtles, etc.).	
Have students closely observe these specimens.	How are these organisms alike? How are these organisms different? How could we group these organisms?
Have students recognize that the organisms that belong to the phylum Arthropoda belong together because of structural similarities, such as exoskeleton, jointed appendages, body segments and compound eyes.	
Have students separate the arthropods from the other animals.	What structural differences are there which can be used to separate arthropods into smaller groups?
Have students count the number of appendages on each arthropod.	How could we use structural differences to classify the arthropods?
Have students separate the arthropods into five distinct classes on the basis of numbers of appendages.	What have we used to classify the animals that belong the class Arthropoda? (structural similarities)
Optional Activity: Students may wish to investigate the classification of the class Insecta.	

Summary Statement: Arthropods can be classified according to their structural similarities.

Auxiliary Words: arthropods, appendage, exoskeleton, compound eyes

References:

Blanc, Sam S., Fischler, Abraham S., Gardner, Olcott, *Modern Science I*. New York: Holt, Rinehart, and Winston, 1963.

Brandwein, Paul F., et al., *The World of Living Things*. New York: Harcourt, Brace and World, 1965.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: The environments of living things have changed over the ages.

Title: High and dry fossils - local evidence of a changed environment

ACTIVITY	QUESTIONS
Write the above "concept" on the chalk board.	What is meant by environment? What, if any, evidence do we have locally to support the statement on the board?
The abundant local evidence is in the form of fossils of marine organisms that are found in earth far above and out of water. This indicates that the areas in which these fossils are found were either under water at one time, or that there has been upheaval of land masses -- in either case an environmental change.	
A study should be made of these fossils: (suggested ways follow)	
1. Field trip to Scientists' Cliffs, Calvert County, Maryland	
2. Some of your students will probably have some fossil shells which they have collected locally. Let them report to the class on where they found them, what they are, etc.	
3. Search references for information pertaining to fossils of Maryland. (See reference list at end of activity.)	What environmental conditions were necessary for the survival of these types of animals? How do we know that these environmental conditions do not exist today in the areas where these fossils are found?

Summary Statement: The location of fossils of marine organisms indicates that the environment has changed in these localities.

Auxiliary Terms: fossils, marine

References: Miocene Fossils of Maryland, Bulletin Number 20. State of Maryland, Department of Geology, Mines and Water Resources. Baltimore: Waverly Press, 1957. (May be obtained from Department of Geology, Mines and Water Resources, Johns Hopkins University, Baltimore, Maryland 21218. $1.00 per copy)

Clark, W. B., et al., Eocene. Systematic Reports, Maryland Geological Survey, State of Maryland, Department of Geology, Mines and Water Resources. Baltimore: The Johns Hopkins Press, 1901, reprinted 1963. (available from same source as previous booklet at $2.50 per copy)

(These references can probably be borrowed from the Enoch Pratt Library through your local library.)

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: The environments of living things have changed over the ages.

Title: Glaciers - proof of environmental change

ACTIVITY	QUESTIONS
	What else might be considered as evidence for the statement that the environments of living things have changed?
The concept of glaciers may or may not be raised. If not, ask. . .	What are glaciers? Where are glaciers located in the world today? In which direction are the world's glaciers moving? How could glaciers be considered as evidence of environmental change?
Note to Teacher: Students should become involved with research that presents the geological evidence that glaciers did extend much further south than they do now. (See reference list.)	
	What are glacial moraines? Drumlins? Erratics? Eskers? What are some of the states in which these glacial deposits are found? Are glaciers located in these states now? What indication do we have then that the climate (environment) of these areas has changed with time?

Summary Statement: The deposits left behind by receding glaciers prove that the climate has changed over the ages.

Concept Term: glacier

Auxiliary Terms: moraine, erratics, drumlins, eskers

References: Namowitz, Samuel N., Earth Science - The World We Live In. Third Edition. Princeton: D. Van Nostrand, 1965. (very good)

MacCracken, Helen Dolman, et al., Basic Earth Science. Syracuse, The L.W. Singer Company, 1964.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: The environments of living things have changed over the ages.

Title: The surface of the earth is continually changing

ACTIVITY	QUESTIONS
Note to Teacher: Essential to the understanding of this concept is a realization of the many changes that have occurred and are continuing to occur in the earth's crust - as evidenced by earthquakes, erosion, floods, diastrophism and volcanism. Students will probably need to use references and films, suggested below, could be used. The best references for this topic are probably Earth Science texts.	

Summary Statement: The earth's surface, as evidenced by volcanism, diastrophism, erosion, earthquakes, flood, etc., has changed in the past and is continuing to change.

References:

MacCracken, Helen Dolman, et al., Basic Earth Science. Syracuse: The L. W. Singer Company, 1964.

Namowitz, Samuel N., Earth Science - The World We Live In. Third Edition. Princeton: D. Van Nostrand, 1965.

Film, 1955 Eruption of Kilanea Volcano - Hawaiian Islands. U. S. Geological Survey, Information Office, Washington, D.C. 20242. (Order several months in advance. There is no fee.) This film is also available from Enoch Pratt Film Library through the County Library. (Order, at least, three weeks in advance.

Film, Erosion. Soil Conservation Service, Motion Picture Library, Unit A-4, 30 South State Road, Upper Darby, Pennsylvania 19082. (Order four weeks in advance and give alternate dates.)

Film, Raindrops and Soil Erosion. Soil Conservation Service, Motion Picture Library, Unit A-4, 30 South State Road, Upper Darby, Pennsylvania 19082. (Order four weeks in advance and give alternate dates.)

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Living things have changed over the ages.

Title: The ancestors of man

ACTIVITY	QUESTIONS
Have student groups do research on the ancestors of modern man.	Who was Java man? Who was Peking man? Who was Neanderthal man? Who was Cro-Magnon man? What are some of the characteristics of each of these ancestors of modern man? When did each group live? What evidence do we have to support these statements? How long has modern man been on earth? How is modern man different from his ancestors? What does the fossil evidence reveal about the development of modern man? (Like other species, man has changed over the ages.)

Summary Statement: The development of modern man progressed through the ages.

Concept Terms: Cro-Magnon, Neanderthal, Java man, Peking man

References:

Brandwein, Paul F., et al., The World of Living Things. New York: Harcourt, Brace and World, 1964.

Kroeber, Elsbeth, et al., Biology. Second Edition. Boston: D. C. Heath and Company, 1965.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Living things have changed over the ages.

Title: Changes in plants

ACTIVITY	QUESTIONS
Have available pictures of forests from Carboniferous period for students to observe. Have students identify the group (subphylum) to which the plants belong. (In the references, listed at the end of this activity, pictures can be found.)	What kind of plants are these? When did they exist? What evidence do we have that they existed?
Show students fossils or pictures of fossils containing fossilized plants. Fossils may be obtained from Carolina Biological Supply Company, Burlington, North Carolina.	What group of plants are represented by these fossils? What kinds of plants do we have today that are not shown in these pictures? Why don't we find fossil evidence of flowering plants from this period?
Refer students to references for research.	What are some plants of this same group that exist today?
Have available examples, living or preserved, of this group, such as ferns, "running cedar", "crow's-foot", and other club mosses and horsetails.	How have the plants from this group changed? How have other plants changed? Why are some of the plants pictured no longer in existence?

Summary Statement: There is fossil evidence that plants have changed over the ages.

Concept Term: Carboniferous period

References:

Heimler, Charles, Principles of Science. Columbus: Charles Merrill Books, Inc., 1966.

Kimball, John W., Biology. Reading: Addison-Wesley Publishing Company.

Mallinson, George G., Science in Modern Life. New York: Ginn and Company, 1964.

Namowitz, Samuel N., Earth Science - The World We Live In. Princeton: D. Van Nostrand, 1965.

Ramsey, William L. and Burckley, Raymond A., Modern Earth Science. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Living things have changed over the ages.

Title: History of the horse

ACTIVITY	QUESTIONS
Have students describe the appearance of the modern horse.	How large is the modern horse? What kind of teeth does the modern horse have? (teeth for a herbivorous diet) How many toes does a modern horse have? How long have horse-like animals lived on the earth? How do scientists know this? How were the early horses different from those you know today?
Do research on the early history of the horse, with emphasis on changes in size, teeth, feet, etc.	What are some other kinds of animals whose ancestors were different from those who live today?
Students may be interested in developing the history of the camel and elephant.	

Summary Statement: The horse is an example of an organism that has undergone change over a long period of time.

References:

Baker, Arthur O., et al., New Dynamic Biology. Chicago: Rand McNally and Company, 1959.

Beauchamp, Wilbur L., Science Problem 3. Chicago: Scott, Foresman and Company, 1957.

Brandwein, Paul F., et al., The World of Living Things. New York: Harcourt, Brace and World, 1965.

Ipcar, Dahlov, Horses of Long Ago. New York: Doubleday and Company, 1961.

MacCracken, Helen Dolman, et al., Basic Earth Science. Syracuse: The L. W. Singer Company, 1964.

Mason, John M. and Peters, Ruth T. Life Science: A Modern Course. Princeton: D. Van Nostrand, 1965.

Film, The Fossil Story. Shell Oil Company, 149-07 Northern Boulevard, Flushing, New York 11354.

Film, Story In the Rocks. Shell Oil Company, 149-07 Northern Boulevard, Flushing, New York 11354.

Kadochrome Slides, Changes in the Horse. American Museum of Natural History, New York City.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Living things have changed over the ages.

Title: Archaeopteryx

ACTIVITY	QUESTIONS
Research on first birds (Archaeopteryx).	What were birds like 150 years ago? How did birds look 150 million years ago? How could we find out what birds looked like 150 million years ago? What was the first bird? What were his ancestors? What evidence is there that these animals were his ancestors? What was his environment like? How was he structurally adapted to his environment? How have birds changed?

Summary Statement: Birds developed from reptiles to adapt to a changing environment.

References:

Biological Sciences Curriculum Study, BSCS Green Version, High School Biology. Chicago: Rand McNally and Company, 1963.

Brandwein, Paul F., et al., The World of Living Things. New York: Harcourt, Brace and World, 1964.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Living things have changed over the ages.

Title: Story In the Rocks, film

ACTIVITY	QUESTIONS
Show the film Story In the Rocks which shows how scientists have reconstructed what life was like in the past by using fossil evidence.	

Reference: Film, Story In the Rocks. Shell Oil Company,
149-07 Northern Boulevard, Flushing, New York 11354.
(This film should be ordered six weeks prior to showing.)

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Changes in the genetic code produce changes in living things.

Title: Changes in living things

ACTIVITY	QUESTIONS
Have for student observation wild-type Drosophila and mutated types of Drosophila, such as brown, brown vestigial, dumpy vestigial, and sepia. Also have albino and normal corn seedlings.	
Have students observe with hand lens wild-type Drosophila then compare mutated types with wild-type.	What differences do you observe between these flies? What do we call these differences? (mutations) What does the word mutation mean?
Have students observe the normal and albino corn seedlings.	What differences do you observe between these plants?
Note to Teacher: After using the corn seedlings plant them for later use.	What are organisms without pigment called? What other organisms, that you know, have mutated?

Summary Statement: Mutations cause changes in organisms.

Concept Terms: mutation, albino

Reference: Mason, John M. and Peters, Ruth T., *Life Science: A Modern Course*. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Changes in the genetic code produce changes in living things.

Title: Mutations in Drosophila

ACTIVITY	QUESTIONS
Note to Teacher: This activity can be done using research or by using the activity as written.	What are some of the causes of mutations? What organisms can be used to investigate mutations? Why?
Note to Teacher: Drosophila may be used because they are easily obtained, require very little space and food and reproduce rapidly with large numbers of offspring.	
Obtain Drosophila and instant Drosophila media from supply company. (Should be ordered at least two weeks in advance.) Etherize flies and have students observe, using hand lens. Discuss characteristics: eye color, wing size and shape and body size, etc. After observation, several cultures of adult flies in fresh media should be set up. One culture should be exposed to X-rays, one to formaldehyde, one to nitrous oxide, and one to heat at near the flies' maximum tolerance. Heat should be applied for one hour. After being exposed to these different conditions, place cultures in 20° to 25° C temperature and allow to reproduce. Have students observe offspring using hand lens.	What differences do you observe in these offspring? What do we call these differences? (mutations) What caused these mutations? What part of the organisms were affected by the various treatments? How does this cause changes in genes? Why didn't all the flies have mutations?

How were the mutations different?
How will these mutations affect these flies if they are returned to their natural environment?

Summary Statement: Mutations may be caused by radiation, chemicals and heat.

References:

Barnett, Lincoln, The Wonders of Life on Earth. New York: Time, Inc., 1960.

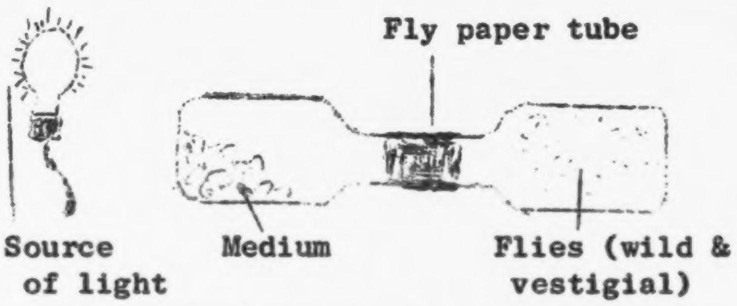
Morholt, Evelyn, et al., A Sourcebook for the Biological Sciences. New York: Harcourt, Brace and World, 1958.

Film, Radiation and the Population. United States Atomic Energy Commission, Division of Public Information, Washington, D. C. 20545. (Order three weeks in advance.)

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Changes in the genetic code produce changes in living things.

Title: Harmful mutations

ACTIVITY	QUESTIONS
Have on hand cultures of Drosophila - wild type and vestigial wing. Have students observe differences.	What differences do you observe in these flies? What do you call traits that have changed? Which of these flies is best adapted to its environment? (Depends on the type of environment in which they live.) How could we find out?
Set up the following exercise:  Fly paper tube Source of light Medium Flies (wild & vestigial) The two bottles should be connected with a tube made from fly paper. One bottle should contain the flies and the other should have media in it. Also set up a light next to the bottle that has the media in it. After twenty-four hours determine the number of each type of fly that was able to reach the media.	Which flies did you find in the container with the media? How did they get there? Why didn't the other flies move to the container with the media? How did this mutation affect the flies' ability to survive in this type of environment? What other mutations do you know of that are harmful to the organism?
Examine the albino and regular corn that was planted from the previous exercise.	What effect did the mutation have on this corn? Why?

Summary Statement: Some mutations are harmful because they render organisms less well adapted to their environments.

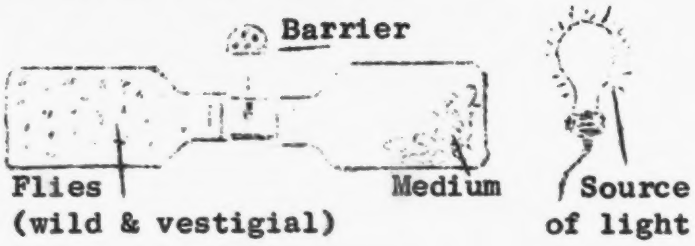
References: Fitzpatrick, Frederick L., *Modern Life Science.* New York: Holt, Rinehart and Winston, 1966.

Mason, John M. and Peters, Ruth T., *Life Science: A Modern Course.* Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: LIVING THINGS ARE IN CONSTANT CHANGE.

Concept: Changes in the genetic code produce changes in living things.

Title: A helpful mutation

ACTIVITY	QUESTIONS
Have available cultures of Drosophila - wild type and vestigial wing, for student use.	In what kind of environment would this mutation be helpful to the fly? How could we find out?
Allow as much time as necessary for students to explore their own ideas. With some help, some students may find an environment in which vestigial wings would be an advantage over normal wings. If no answer is arrived at have them set up the following exercise.  Barrier Flies (wild & vestigial) Medium Source of light	
Have two glass bottles connected with a cardboard tube. Near the center of this tube place as a barrier, a perforated stop with fly paper covering all except the perforations. The bottom of the stop should not reach the bottom of the tube so that the flies can walk under. Fruit flies will try to move toward the light. The wild type will try to fly and when they light to get through the perforations will get caught on the fly paper. The vestigial wing flies will walk through the tube under the stop.	Which of the flies made it through in greater numbers? Why were they better able to make it through? How did the mutation help these flies? How were they better adapted to the environment than normal flies?

Students may need to do research to find helpful mutations and why they are helpful.	What other mutations do you know of that are helpful to organisms? Why are they helpful?

Summary Statement: Some mutations are helpful in that they increase an organism's adaptation to the environment.

References:

Fitzpatrick, Frederick L., Modern Life Science. New York: Holt, Rinehart and Winston, 1966.

Mason, John M. and Peters, Ruth T., Life Science: A Modern Course. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are daily changes on Earth.

Title: Weather factors

ACTIVITY	QUESTIONS
	What conditions are characteristic of the various seasons? (rain, heat, wind) What do we call these characteristics? (weather) How constant is "weather"? What causes these variations? (basically heat) How do changes in heat affect our weather? How can we find out?
Note: Let students try to show the various effects of heat on weather. Suggested activities: 1. lamp chamney to show hot air rising 2. convection apparatus to show currents caused by hot air rising and cold air falling 3. heating soil and water and allowing it to cool to show causes of various local air currents 4. a review of the Earth's inclination to show the formation of large warm air masses due to direct rays from the sun	
The way the previous exercises are used will depend upon the class and teacher. But it is suggested, when possible, to divide the students into groups and let them investigate the above topics.	What happens to air as it is heated? What happens to air as it is cooled? What are the differences in the rates of heating and cooling of different kinds of earth surfaces? (soil, water, rocks, etc.) What effect does this have on air currents?

Optional: Have students do research on the effects of unequal heating of the earth's surface on winds.

Summary Statement:	Air currents are caused by uneven heating of the earth's surface.
Concept Terms:	weather, air currents
References:	Davis, Ira C., et al., *Science 3, Discovery and Progress*. New York: Holt, Rinehart and Winston, 1965. Blanc, Sam S., Fischler, Abraham S., and Gardner, Olcott, *Modern Science I*. New York: Holt, Rinehart and Winston, 1963. Namowitz, Samuel N., *Earth Science - The World We Live In*, Princeton: D. Van Nostrand Company, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are daily changes on Earth.

Title: Air masses

ACTIVITY	QUESTIONS
	Which part of the earth receives the most direct rays of the sun and, therefore, the most heat? What effect does this have on the air and water in these areas? What happens to the large masses of air that form at the equator?
Have on hand weather maps. Use weather maps from newspapers or they may be obtained from the weather station on the Naval Air Station or from the Weather Bureau.	How would you explain the movement of warm air toward cooler air when we have seen that the opposite occurs in local situations?
Have on hand a large globe or ball which will spin on an axis. Place a drop of washable paint or ink at the equator. Spin the ball to show that the liquid will move much as air currents from the equator move. This may also be done to show the movement of cold air masses from the North Pole.	What are the characteristics of the warm air masses which reach us from the equator? (light, moist, etc.) What determines the amount of moisture the air will hold? What do we call the moisture in the air? What happens when warm air containing moisture comes into contact with a cold object?
Have students place ice in a dry beaker and let stand for a few minutes and observe. Have them record their observations.	What happened on the outside of the beaker? What caused this? What relationship can you see between this and precipitation?

Summary Statement: Warm, moist air masses are found near the equator; as they rise and move northward, due to the spinning of the earth, they cool and cause precipitation.

Concept Term: air masses

References:

Davis, Ira C., et al., *Science 3, Discovery and Progress*. New York: Holt, Rinehart and Winston, 1965.

Blanc, Sam S., Fischler, Abraham S., and Gardner, Olcott, *Modern Science I*. New York: Holt, Rinehart and Winston, 1963.

Namowitz, Samuel N., *Earth Science - The World We Live In*. Princeton: D. Van Nostrand, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are daily changes on Earth.

Title: Clouds and precipitation

ACTIVITY	QUESTIONS
	What is a cloud? How is a cloud formed? How could we make a cloud in this room?
Use vacuum-type cloud chamber to simulate cloud formation.	How do you explain what happened? What relationship does this suggest between air pressure and weather? What seems to be necessary for cloud formation? (moisture, particles and dew point) What causes the different forms of clouds?
Have students do research on different forms of clouds and their causes.	What is the relationship of the type of cloud to precipitation?
Note: The answer to this question will probably be known from the previous research. If not, the students may do research on this topic.	

Summary Statement: Clouds are formed by moisture condensing on particles in the air and are responsible for precipitation.

Concept Term: dew point

References:

MacCracken, Helen Dolman, et al., Basic Earth Science. Syracuse: The L. W. Singer Company, 1964.

Namowitz, Samuel N., Earth Science - The World We Live In. Princeton: D. Van Nostrand, 1965.

Ramsey, William L. and Burckley, Raymond A., Modern Earth Science. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are daily changes on Earth.

Title: **Forecasting weather**

ACTIVITY	QUESTIONS
Review factors responsible for weather.	How can these factors be used to predict weather?
Have students look at weather map.	What do you find on the map? How are these things measured?
Have students do research on weather instruments. Have them make a list and then divide into groups to make the various instruments. The following is a suggested list of instruments: 1. thermometer 2. barometer 3. anemometer 4. psychrometer 5. rain gauge	
Have them present the instruments to the class. While the students are working on this, have the students follow the weather map so that the students can determine the correlation between the various factors shown on the map.	
A valuable resource for this activity is the weather station on the Naval Air Station. A field trip to the weather station or a meteorologist from the weather station could come into the classroom and demonstrate the use of balloons in weather forecasting.	
Research: unusual kinds of weather (hurricanes, tornadoes, etc.)	

Summary Statement: Special instruments are used to gather information useful in predicting the weather.

Concept Terms: thermometer, barometer, anemometer, psychrometer, rain gauge

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are daily changes on Earth.

Title: Unchained Goddess (film)

ACTIVITY	QUESTIONS
Note to Teacher: Show the film, Unchained Goddess, which explains what causes weather and shows what scientists are doing to predict it and to attempt to control it.	

Reference: Film, Unchained Goddess. C and P Telephone Company of Maryland, Business Office, Leonardtown, Maryland. (Order this film two weeks prior to showing.)

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are regular movements of the Earth and Sun.

Title: Phases of the Moon

ACTIVITY	QUESTIONS
This activity should be started as a homework assignment one month prior to the time the information is needed. Have students observe and record the time at which the moon rises each day, its position in the sky and apparent shape of the moon. (Data on time moon rises can be obtained from the newspaper or almanac.) Note to Teacher: Some students may need research to answer these questions.	What did you observe about the time the moon rose each night? Why didn't the moon rise at the same time each night? What was the location of the moon each night, in relation to the horizon? Why did it change position? What was the shape of the moon each night? Why did the shape change? How can we find out?
Students may devise ways to show how much of the moon's lighted surface is observable to people on Earth. Or use the activity, found in the book by Thurber and Kilburn, Exploring Science Seven, page 72, to show phase changes similar to the moon's.	What did you observe happening? What do we call these different phases of the moon? (crescent, quarter, gibbous, full, new moon) How long does it take for the moon to go through all its phases? What do the phases of the moon tell us about its relationship to the earth?

Summary Statement: Phases of the moon are caused by the revolving of the moon around the earth.

Concept Terms: phases of moon, crescent, gibbous

References:

Thurber, Walter A. and Kilburn, Robert E., Exploring Science Seven. Rockleigh: Allyn and Bacon, Inc., 1966.

Namowitz, Samuel N., Earth Science - The World We Live In. Princeton: D. Van Nostrand, 1965.

Davis, Ira C., et al., Science 3 - Discovery and Progress. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are regular movements of the Earth and Sun.

Title: Rotation of the earth on its axis

ACTIVITY	QUESTIONS
Using a globe, illustrate and elicit the answers to the following questions.	What is meant by the earth's equator? What is meant by the earth's poles? What is meant by the earth's axis? What is responsible for "day" and "night" in each twenty-four hour period? Does the sun really "rise" in the east, move across the sky, and then "set" in the west? What evidence do we have to support the theory that the earth completely rotates on its axis once in every twenty-four hour period?
Students will probably not know the evidence, hence, on the next questions which lead to the evidence of "star trail."	What is the name of the star to which the earth's axis points in the northern hemisphere? Assuming that the earth rotates on its axis, how would Polaris appear to move if you observed it from the north pole? (It would not appear to move at all.) How would the other stars around Polaris appear to move? (in circular courses) How can we gather evidence to support this?
Let students suggest ways and, regardless of what is suggested, lead them to the following activity "Photographing Star Trails." Using an ordinary camera, set it so it points to Polaris (the pole star) and expose a film for several hours on a clear, moonless evening, using the full aperture of the lens and having the focus adjusted for distance.	

This must be done in a place where there will be no interference from other light sources. Develop and print the film. (A Polaroid camera would be very convenient.)

What are the "trails" on the film?
Why do they appear in a circular pattern?
What does this indicate about the rotation of the earth?

Summary Statement: The apparent circular motion of stars around the pole star is considered as evidence that the earth rotates on its axis.

Concept Terms: axis, rotation, poles, equator

References: Thurber, Walter A. and Kilburn, Robert E., Exploring Earth Science. Rockleigh: Allyn and Bacon, 1966.

Ramsey, Phillips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are regular movements of the Earth and Sun.

Title: Foucault's Pendulum - evidence of the earth's rotation

ACTIVITY	QUESTIONS
	We have seen how the apparent movement of stars is considered as evidence of the earth's rotation. What is considered as additional evidence for this theory? Who was J.B.L. Foucault and what part did he play in this theory of the earth's rotation?
Students should do research to find the answer to these questions. Set up a model of this pendulum for a demonstration: Support a heavy pendulum bob by a wire from the ceiling. Attach a pin or similar object to the bottom of the bob so that when it moves it will trace a path in a layer of fine sand placed under it. The trace left by the swinging pendulum indicates its plane of swing. If, while the pendulum is swinging, the table in which the layer of sand is placed is slowly turned, the pin will cut new traces in the sand to indicate the circular motion of the table top. The plane of the swing of the pendulum thus serves as a means of indicating the rotation of the table top. (If a long enough pendulum could be fashioned so it would swing for a long time, the earth's rotation could be seen.) In one hour the plane of the pendulum's swing should change about 8° (at this latitude), at the North Pole the change would be 15° in one hour.	
	What does the rotating table represent in this demonstration? How does Foucault's Pendulum serve as evidence of the earth's rotation? What daily phenomenon is explained by the earth's rotation?

Summary Statement: Foucault's Pendulum is considered as convincing evidence of the earth's rotation.

Concept Terms: Foucault's Pendulum, rotate

References: Namowitz, Samuel N., *Earth Science - The World We Live In.* Third Edition. Princeton: D. Van Nostrand, 1965.

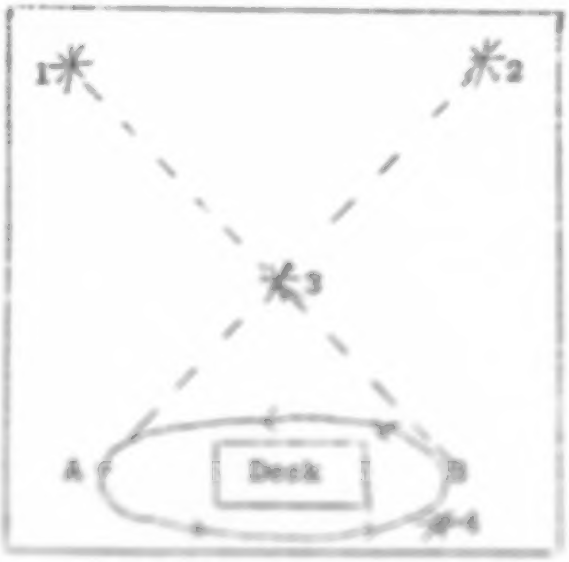
Ramsey, William L. and Burckley, Raymond A., *Modern Earth Science.* New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are regular movements of the Earth and Sun.

Title: The revolution of the earth as shown by parallax of stars

ACTIVITY	QUESTIONS
	Do the names Ptolemy and Copernicus mean anything to you?
	We have discussed the rotation of the earth on its axis, are there any other motions of this plant? What are they?
	At one time in the history of man, there were two conflicting viewpoints with regard to motion of the earth: (1) the earth revolves around the sun; (2) the sun revolves around the earth.
	Which theory is considered true today? What evidence do we have that the earth revolves around the sun?
Research Ptolemy and Copernicus, then research parallax to support Copernicus' viewpoint. Demonstrate parallax. Position four students as follows: put two in opposite corners in the back of the room; let the third student stand at the mid-point of the room. Place a desk at the front of the room in line with the third student. Let the fourth student walk in an orbit around the desk. See diagram below:	



Students 1 - 3 stand for stars, student 4 stands for the earth, and the desk stands for the sun. As number 4 walks in a large circle (the "earth's orbit") around the desk, the position of the nearest student will seem to change in relation to the two students at the rear of the room. At point A on the circle, ask first question.	Where is student 2 in relation to student 3? (Student 3 will appear almost in line with student 2.)
At point B, almost in line with student 1, ask the next question.	Where is student 2 now in relation to student 3?
(A similar phenomenon is observed with near and distant stars as the earth revolves around the sun.)	What appeared to happen to the positions of 1 and 2 in relation to 3 as you moved around the desk?
	Would the relative positions of your classmates change if you did not view them from two different points?
	What do we call the apparent shifts in position of near and distant stars when viewed from earth at different times of the year?
	What causes this apparent change in position?

Summary Statement: Parallax of stars is considered evidence that the earth revolves around the sun.

Concept Terms: parallax, revolves

References:

Jacobson, Willard J., et al., Adventures in Science. New York: American Book Company, 1964.

Namowitz, Samuel N., Earth Science - The World We Live In. Third Edition. Princeton: D. Van Nostrand, 1965.

Ramsey, William L. and Burckley, Raymond A., Modern Earth Science. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are regular movements of the Earth and Sun.

Title: The inclination of the earth's axis

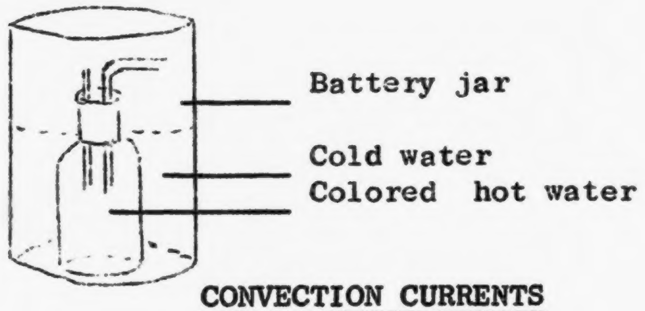
ACTIVITY	QUESTIONS
	We have seen evidence for the earth's revolving around the sun and for rotating on its axis. What is the position of the earth's axis?
Students research the answer to this.	What effects do the tilt of the earth's axis and its rotation and revolution have on us?
Note to Teacher: Included in the answer to this question are: 1. day and night 2. changes in hours of daylight and darkness 3. the year 4. seasonal changes (investigated in conceptual scheme F-3) The topics should be researched by the students and demonstrated by the students or the teacher.	

Summary Statement: The tilt of the earth's axis (together with the earth's rotation and revolution) have strong influences on earthly phenomena.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are regular movements of the Earth and Sun.

Title: Ocean currents

ACTIVITY	QUESTIONS
	What is the Gulf Stream? What causes it? What other currents are there in the ocean? How can we find out?
Obtain charts and maps pertaining to wind and ocean currents from: Director Coastal Geodetic Survey Washington Scientific Center Rockville, Maryland	
Note: Enclose self addressed envelope with fifteen cents postage.	How do the winds affect water circulation? How does the Earth's rotation affect water circulation? How does temperature affect water circulation? How can we demonstrate the effect of temperature on the circulation of water?
When a bottle, containing two tubes connected as shown in the diagram below, is filled with colored hot water and lowered to the bottom of a jar of cold water convection currents will result. (Convection: process of conveying heat by currents in gases and liquids.) Illustration:  CONVECTION CURRENTS	

	What do you think would happen if this type of set up were reversed?
Reverse the set up.	What do you observe? How can you explain what happened? What name do scientists give to this type of movement? (current)

Summary Statement: The three major factors which cause ocean currents are wind, the earth's rotation and temperature.

Concept Term: current

Auxiliary Words: convection, circulation, rotation, temperature

References:

Davis, Ira C., et al., Science 3, Discovery and Progress. New York: Holt, Rinehart and Winston, 1965.

Jacobson, Willard J., et al., Investigations in Science. New York: American Book Company, 1965.

Wolfe, Battan, Fleming, Hawkins, Skornik, Earth and Space Science. Boston: D. C. Heath and Company, 1966.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: There are regular movements of the Earth and Sun.

Title: **Tides**

ACTIVITY	QUESTIONS
	What do we call the force exerted on Earth by the Moon? (gravity) What part of Earth is affected most? What does this effect cause? (tides) How might we investigate this?
Materials needed: one large ball, a small globe, one small ball, rubber band, two lengths of string, one long, one short (These materials are to represent the sun, earth, moon, oceans and gravitational effects, respectively.) Explain to the students what each item represents and have each group devise its own system. Place a tightly fitting rubber band around the center of the globe. Using the short string attach the small ball to the rubber band. Turn the globe until the ball is over the Atlantic Ocean. Slowly pull the ball away from the Earth.	What happened to the Ocean? What caused this? How many tides do we usually have each day? What causes the other high tide when the moon revolves only once a day? How does it cause this? How can we find out?
Do research to find how inertia causes the bulge on the earth opposite to the moon. An investigation may be set up to show how inertia causes this bulge. Pour about a quart of water into a balloon and tie the opening with a string. Support the balloon of water on the flat of one hand and give the neck of the balloon a sharp pull in a horizontal direction with your other hand.	What did you observe taking place?

	How does this represent the bulge in the ocean caused by inertia? How does the sun affect tides? How could we investigate this?
Attach the large ball to the rubber band with the remaining string. With the Sun and Moon in a straight line on the same side of the earth pull both balls slowly.	What happened to the oceans? Which of the two exerts the greatest force on the earth? What happens when the sun and the moon are not in a straight line?
Do research to find answers.	What other factors influence tides?

Summary Statement: Tides are caused by gravitational pull of the Moon and Sun on the Earth and by inertia.

References:

Davis, Ira C., et al., Science 3, Discovery and Progress. New York: Holt, Rinehart and Winston, 1965.

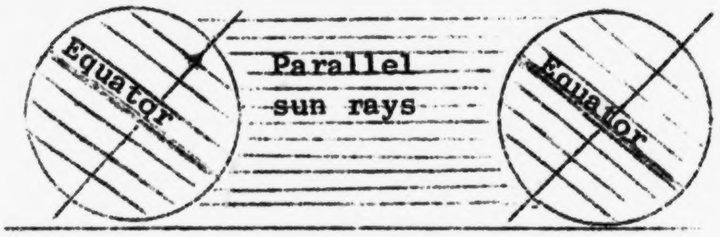
Ramsey, Phillips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Thurber, Walter A. and Kilburn, Robert E., Exploring Earth Science. Rockleigh: Allyn and Bacon, Inc., 1966.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Seasonal and annual changes on Earth and within the solar system can be predicted.

Title: **Seasons**

ACTIVITY	QUESTIONS
	What season is this? What are some of the characteristics of this season? Why do we have seasons? (inclination and revolution) How does the inclination of the Earth affect the amount of light an area receives?
On the chalk board draw the following diagram: 	
Be sure circles representing the Earth are accurate and that lines representing rays of light are parallel and equidistant. Have students connect ends of parallel lines at equator and at poles with straight lines and measure the connecting lines.	Which area of the Earth's surface receives the most concentrated sunlight? What effect does this have on temperature? How could we find out?
Have students set up the following exercise: Fill two pans with soil (preferably dark soil) and place a thermometer in each pan, barely covering the ends of the thermometers with the soil. Put the pans on a sunny window ledge so that one is flat and the other propped up so that the	

surface is perpendicular to the sun's rays. Leave both pans in the sunlight for 25 to 30 minutes and read the thermometer without removing from the soil.

Refer students to the first diagram.

Which pan of soil absorbed more heat?
Why?
What effect does the earth's revolving have on seasons?

During what part of the year does the United States receive the most indirect rays of light from the sun?
What is the coldest time of year?
Why is there a difference?
What other factors influence seasons and weather?

Summary Statement: Seasonal changes are influenced by many factors; the most important are inclination and revolution.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Seasonal and annual changes on Earth and within the solar system can be predicted.

Title: Solar system

ACTIVITY	QUESTIONS
	What is a solar system? What makes up a solar system? What is our solar system like? How can we find out?
Divide students into groups and assign each group one of the planets to do research on. Suggested topics for students' research are: size of planet location with respect to Earth number of moons period of revolution period of rotation distinguishing characterics of each planet comparison with Earth One group of students could construct a bulletin board as part of its report to the class.	

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Seasonal and annual changes on Earth and within the solar system can be predicted.

Title: Origin of the solar system

ACTIVITY	QUESTIONS
	How old is the planet Earth? What evidences are there of the Earth's age? How have scientists formulated their theories of the Earth's age?
Students should explore reference materials to determine Earth's age and methods of arriving at the age.	How did the Earth originate?
Students may want to formulate their own theories of the Earth's origin dealing with such questions as: 1. Which came first, land or water? 2. Was the Earth originally a cold mass or a hot mass? 3. Is the Earth a conglomerate formation of the other smaller bodies of space? 4. Was the Earth originally part of a star?	
These theories should be logically validated with information from readings.	What are some of the widely accepted scientific theories of the Earth's origin? What evidence is there that all of the planets originated in the same way at the same time? What evidence is there that each planet originated at different times in a different way? What scientific theory of the origin of the solar system is most widely accepted? Why?

Summary Statement: There are many theories of the origin of the solar system.

Auxiliary Words: solar system, planet, theory

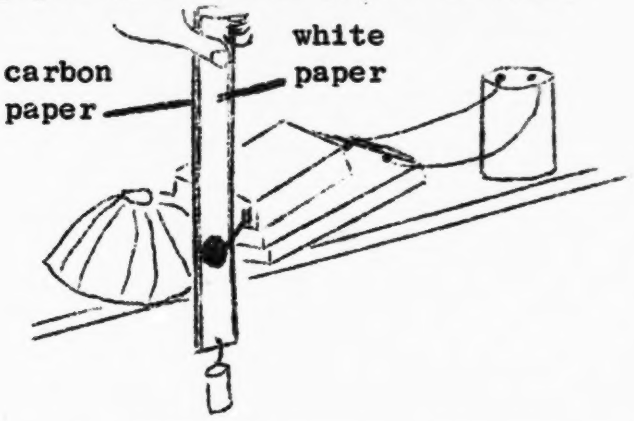
References: Brinckerhoff, Richard, et al., The Physical World. New York: Harcourt, Brace and Company, 1958.

Jacobson, Willard J., et al., Adventures in Science. New York: American Book Company, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Universal gravitation and inertial motion govern the relations of all celestial bodies.

Title: **Freely falling objects**

ACTIVITY	QUESTIONS
Conduct the first part of this activity out of doors, and at a safe distance from windows, automobiles, etc. Have one student throw a ball, or similar object, as high into the air as possible, with the other members of the class observing. Have students observe object as it rises, comes to a stop, and returns to the ground. Repeat several times.	What caused the ball to rise into the air? Why did the ball stop rising? Why did the ball fall back to the ground? When did the ball appear to be moving most rapidly? Why? When did the ball appear to be moving most slowly? Why?
Have students set up apparatus shown below, using two long strips of white paper with carbon paper between:  As the doorbell hammer hits the bell, the pattern of dots will indicate the distance the weight falls in each interval of time.	How do you explain the position of the dots on the paper?

Have students repeat, using heavier and lighter weights.	What effect does the weight of a freely falling object have on its acceleration?
Optional: Some students may be able to devise a method for determining the answer to this question.	How might we determine the acceleration of a freely falling object?

Summary Statement: The speed of freely falling bodies is accelerated by the earth's gravitational force.

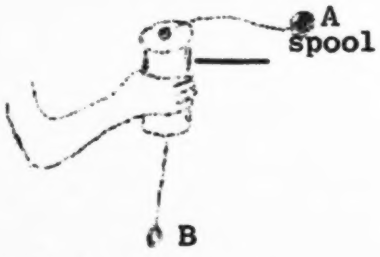
Concept Terms: gravitation, acceleration

Reference: Thurber, Walter A. and Kilburn, Robert E., Exploring Earth Science. Boston: Allyn and Bacon, Inc., 1966.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Universal gravitation and inertial motion govern the relations of all celestial bodies.

Title: **Satellites**

ACTIVITY	QUESTIONS
Review previous activity.	Under what conditions might the ball have "escaped" into space and not returned to the ground?
Have students assemble a spool, a string, and two weights as shown below:	
Students should whirl Ball A at various speeds and observe effect on Ball B.  	What keeps A from flying off when it is whirled? What happens to B when A is whirled rapidly? What do we call the circular path followed by A? What are the forces that keep the moon in orbit around the earth?
Refer to references.	How are man-made satellites placed in orbit?

Summary Statement: Gravitation and inertial motion are responsible for the orbiting of natural and man-made satellites.

Concept Terms: orbit, satellite

References:

Thurber, Walter A. and Kilburn, Robert E., Exploring Science Seven. Rockleigh: Allyn and Bacon, Inc., 1966.

Wolfe, Battan, Fleming, Hawkins, Skornik, Earth and Space Science. Boston: D. C. Heath and Company, 1966.

Namowitz, Samuel N., Earth Science - The World We Live In. 3rd Edition. Princeton: D. Van Nostrand, 1965.

MacCracken, Helen Dolman, Basic Earth Science. Syracuse: The L.W. Singer Company, 1964.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Universal gravitation and inertial motion govern the relations of all celestial bodies.

Title: Measurement in space

ACTIVITY	QUESTIONS
Materials needed: meter or yardsticks	
Have student walk the length of the classroom.	How far did you walk? How could you find out? (Students will probably suggest measuring.) What unit will you use to measure this distance? (feet) How many feet away is (see teacher's note)?
Note: Teacher should select a town or other place well-known to students to complete the preceding question. It should be a known distance in miles.	How else could you express this distance? (Students will probably suggest miles.) Why didn't you learn this distance in feet? (Easier to measure large distance in larger units, such as miles.)
Instruct students to glance at sun for just a second if it is a sunny day.	How far away is the sun? (93 million miles) How did you know this? (Students will probably tell you they learned it in earlier grades.) Why didn't you express this distance in feet or inches?
Have students think about stars, other than the sun, which they have observed.	How many miles from the Earth do you suppose these stars are located? (Students will probably not know but suggest looking in books to find out.)
Allow students to look up distances to stars in an astronomy book.	How many miles from the Earth is the closest star? (Students may not know.) Why? (Distance not given in miles.) What units were used to express this distance? (A unit called light year.)

What is a light year? (Most will not know. A few may suggest distance light travels in one year.)
How fast does light travel? (186,000 miles/sec.)
How did you know? (Learned in earlier grades.)
How far does light travel in one minute?
How could you find out? (Multiply 186,000 x 60)
How far does light travel in one hour?
How could you find out? (Multiply previous answer by 60.)
Why? (60 minutes in one hour.)
How far does light travel in one day?
How did you determine this? (Multiplied above answer by 24 which is the number of hours in one day.)
How far does light travel in one year?
How could you find out?
What do we call the distance light travels in a year? (one light year)

Note: Students will probably give answer of 5,860,000,000,000 which they actually computed. Explain that scientists usually round this figure off to 6 trillion miles for simplifying calculation.

How far is 6 trillion? (Students will have no idea.)
How long do you think it would take you to write to 6 trillion? (Students will have no idea. Many will want to try.)
Why do you think scientists use units such as light years if it is so large that you cannot picture it? (Makes it simpler to measure vast distances of space.)

Have students use books to find the visible star which is farthest from the Earth.

How many light years is this star from the Earth?
Do you think we could ever travel to this star and back?
Why?

Summary Statement: Distances between the Earth and most stars are so great that special unit, the light year, must be used to measure them.

Concept Term: light year

Auxiliary Word: star

References:

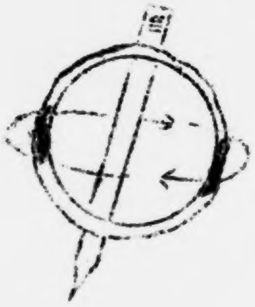
MacCracken, Helen Dolman, et al., *Basic Earth Science*. Syracuse: The L.W. Singer Company, 1964.

Ramsey, William L. and Burckley, Raymond A., *Modern Earth Science*. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Universal gravitation and inertial motion govern the relations of all celestial bodies.

Title: The earth's bulge

ACTIVITY	QUESTIONS
Have students cut out two eight-inch strips of paper about one inch wide and tape them together. Push a pencil through as shown and adjust the strips to form a nearly perfect circle.	
	
Have students measure the diameters from pole to pole and at the equator - then twirl the pencil rapidly and remeasure.	What are the diameters of your circle? Why did the diameters change? Why does the earth bulge at the equators?
Refer students to references.	

Summary Statement: The equatorial bulge of the spinning earth is caused by inertia.

References:

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Thurber, Walter A. and Kilburn, Robert E., Exploring Science Seven. Rockleigh: Allyn and Bacon, Inc., 1966.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

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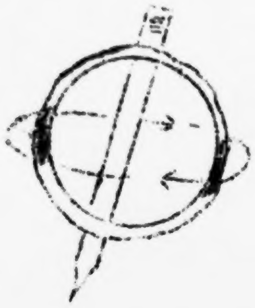	
Have students measure the diameters from pole to pole and at the equator - then twirl the pencil rapidly and remeasure.	What are the diameters of your circle? Why did the diameters change? Why does the earth bulge at the equators?
Refer students to references.	

Summary Statement: The equatorial bulge of the spinning earth is caused by inertia.

References:

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Thurber, Walter A. and Kilburn, Robert E., Exploring Science Seven. Rockleigh: Allyn and Bacon, Inc., 1966.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Universal gravitation and inertial motion govern the relations of all celestial bodies.

Title: Elliptical orbits

ACTIVITY	QUESTIONS
Materials: eight-inch loops of string, thumbtacks, pencils, sheets of heavy cardboard	What is the shape of the earth's orbit around the sun?
Have each group of students stick two thumbtacks three inches apart into a sheet of cardboard. Place the loop of string around the two tacks and stretch tight with the point of a pencil. Move the pencil around the loop, keeping the string tight and drawing a line.	What is the shape of the drawing you have made? How is it different from a circle? How would different distances between the tacks affect the shape?
Have students repeat with tacks at varying distances.	What might cause the earth's orbit around the sun to be other than circular? Who was Kepler?
Refer to references.	

Summary Statement: The motion of planets around the sun is elliptical.

References:

Thurber, Walter A. and Kilburn, Robert E., Exploring Science Seven. Rockleigh: Allyn and Bacon, Inc., 1966.

Ramsey, Philips, Watenpaugh, Foundations of Physical Science. New York: Holt, Rinehart and Winston, 1967.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Changes on earth, erosion and land building occur in predictable sequence.

Title: Soil

ACTIVITY	QUESTIONS
	What is the most important thing to the survival of living things? Why do you think so?
Note: Answers should include: sun, soil and water. Continue discussion emphasizing soil.	What is soil? How is soil used? What do you know about soil? How could we investigate soil?
Have students select an area covered with vegetation and dig a hole about two feet deep. Direct the students' observations to the sides of the hole. Note: A site of natural soil formation should be chosen.	What do you see? How does the appearance of the soil change as the depth increases? What does the soil contain?
Have students record their observations of color, content of gravel, stones, vegetative material, compactness, etc. Students should make a diagram of their observations and a master (composite) diagram could be placed on the chalk board.	How much vegetative material do you see? What colors are present? How porous is the soil? What other characteristic can you identify about this soil sample?
Note to Teacher: Continue to discuss soil sample until students see the layering of soil.	How do you think the layers of soil in this area would compare to the layers of soil in other areas? How could we find out?
Have students dig a hole or observe the side of a gully in their neighborhood. Diagrams should be made and compared.	

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What do you think causes this variation in layers? (soil formation, weathering, vegetative material, climate and other variables)

Summary Statement: Soil is a mixture of rock, bits of dead animals and microorganisms laid down in layers.

Concept Term: soil

Auxiliary Words: layers, porous

References: MacCracken, Helen Dolman, et al., *Basic Earth Science*. Syracuse: The L. W. Singer Company, 1964.

Ramsey, William L. and Burckley, Raymond A., *Modern Earth Science*. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Changes on earth, erosion and land building occur in predictable sequence.

Title: Soil formation

ACTIVITY	QUESTIONS
	What is soil basically made of? (sand, silt, and clay) What is the difference between sand, silt and clay?
Research should be done to find a definition of sand, silt, and clay. Have students bring in soil samples.	How does the amount of sand, silt and clay compare in these soils? How could we find out?
Have students place an equal amount of soil in equal sized jars in equal amounts of water. Shake the jars until the soil is dispersed in the water. Set the jars aside so that soil may settle out. Sand will be seen in a short period of time. Silt will settle in several hours. Clay may take several days to settle. After a reasonable period of time have them compare the amounts (depths of layers) of sand, silt, and clay of various samples.	What does this tell you about various types of soil? How were these particles formed? (friction, chemical reactions and pressure)
Note: The following activities do not have to come in order.	
Have students observe rock samples from western Maryland (rough, sharp edges, etc.) and rock samples taken from one of the local bodies of water (smooth, rounded, etc.).	What caused the smoothness of this rock? What happened to the particles that were broken off? Would wind cause the same appearance as water causes? How can you prove this?

Pictures may be obtained of wind erosion.	What else could cause rocks to break into smaller particles? (chemical reactions) What would cause these reactions in nature?
Test rain water to determine the pH. It should be acidic. Take some hydrochloric acid and let it represent the acidic tendency of rain water. Place a few drops on some limestone.	What is causing the bubbles? What is happening? What would we have if the acid, which was in contact with this rock, were passed through filter paper? How can plants break rocks into smaller particles? (pressure caused by growing roots) How else does pressure break up rocks? (freezing water)
Fill a narrow necked jar with water. Freeze it. The jar will crack. Do not use a jar and lid as this does not represent freezing as it occurs in relation to the breaking of rocks.	

Summary Statement: Soil formation is going on constantly.

Concept Term: soil

Auxiliary Words: layers, porous, sand, silt, clay, pH

References:

MacCracken, Helen Dolman, et al., Basic Earth Science. Syracuse: The L. W. Singer Company, 1964.

Ramsey, William L. and Burckley, Raymond A., Modern Earth Science. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Changes on earth, erosion and land building occur in predictable sequence.

Title: Land building

ACTIVITY	QUESTIONS
	What is land building?
Review land and water formations activity found in the Science Curriculum Guide, Volume III.	What types of land buildings are going on today? Where are these changes taking place? How do you know what type of land building is going on? Where can we find out where land building is taking place?
Have students do research on mountains, volcanos, valleys, etc.	
Obtain land building information from:	
Director, Coast and Geodetic Survey Washington Scientific Center Rockville, Maryland	
Use resource personnel from the Naval Air Station Oceanographic Survey Unit, Patuxent River, Maryland.	What is the function of the Geodetic Survey Organization? What is the function of the Oceanographic Agency?

Summary Statement: Land building is an on going process.

Concept Term: land building

Auxiliary Words: geodetic, oceanography

References: Earth Science Curriculum Project, Investigating the Earth. Boulder: American Geological Institute, 1965.

Film, The Earth's Changing Surface. New York: McGraw-Hill Text Films, 1961.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Changes on earth, erosion and land building occur in predictable sequence.

Title: Erosion

ACTIVITY	QUESTIONS
	What do you see if you look into a stream after a rain? Where did this mud come from? How much rain does it take to move soil? How can we find out?
Have students take a dropper and let water fall one drop at a time on a container of loose, fine grained, dry soil. Place a circle of paper around the impact point of the drop. Let the paper dry and observe the amount of soil on the paper.	
	What things would you say are important in deciding the effects of rain on soil? (amount and force of water, compactness of soil, soil type, vegetative cover, and slope) How can we see the effects of these variables?
Let the students set up experiments using soil, water, sod, and anything else they want to use to show the effects of variables on erosion. Have them make accurate records of what was done, how it was done, and the outcome. Compare the various results.	
	What is the best situation as far as preventing soil erosion by rain and run off? Why can't this situation always be achieved? If the ideal situation is not always achievable, what can be done to slow the process of water erosion due to rain and run off? How can we test this?
Have students do research on erosion control practices. Using the same materials as above test the operation of these practices.	
	What ways does water move soil other than by rain?

Students will probably have come across this in their previous reading on erosion control.	How can stream bank erosion be stopped?
Using a large shallow box or pan filled with sand show the effects of various wind breaks on soil by using a fan. (This may best be done outside if an outlet is available.)	How can stream bank erosion be prevented? What other cause of erosion is there? What can be done to prevent this? What are some forms of wind breaks found in this area? How effective are they? How can we find out?
Have students list and compare erosion controls they see in one day. This should be done from observation, not memory.	Why must erosion be controlled? How much of a problem is erosion in this area? How many forms or ways of controlling erosion do you see in one day?

Summary Statement: Soil erosion is a serious problem which can be controlled.

References:

MacCracken, Helen Dolman, et al., Basic Earth Science. Syracuse: The L. W. Singer Company, 1964.

Ramsey, William L. and Burckley, Raymond A., Modern Earth Science. New York: Holt, Rinehart and Winston, 1965.

Conceptual Scheme: THE UNIVERSE IS IN CONSTANT CHANGE.

Concept: Nuclear reactions produce the radiant energy of stars.

Title: **Stars: celestial reactions**

ACTIVITY	QUESTIONS
Materials needed include substances required to build models of atoms and one or more small air pumps such as a tire pump.	
	What are some natural objects you will see in the sky on any clear night? (Someone will probably mention stars.) Where do stars originally come from? (Students may not know.) How could you find out? (Someone may suggest looking in books.)
After doing research, make certain they understand that stars may have come from clouds or gas and dust found in space.	
	What are all bodies in space (including dust, gas, clouds) constantly doing? (moving) What do you think would happen as particles of gas or dust moved closer together?
Hold up air pump.	What is inside the barrel or cylinder of this pump? (molecules (particles) of air)
Push piston of pump down into cylinder.	What happens to air particles when the handle is pushed down?
Work handle of pump up and down several times as quickly as possible. Have student feel barrel of pump.	How does the barrel feel? Why? (Molecules of air are being squeezed together very rapidly.) What do you suppose happens to the gas and dust particles in space when they come close together? (They also get hot due to the pressure.)
Emphasize that the amount of heat produced in space is much greater than that produced by the air in the pump. Review making models of atoms.	

Instruct students to make models of ordinary hydrogen nuclei.	What element makes up most of the gas in space and in stars? (Students may mention hydrogen.) How many protons does an ordinary hydrogen nucleus contain? How many neutrons does an ordinary hydrogen nucleus contain? (zero) What would happen if you added one proton to your model?
Instruct students to add a proton to their hydrogen models.	What do you have now? (deuterium, an isotope of hydrogen) What would be needed for a real hydrogen atom to join with another proton? (energy) Where would a hydrogen atom in a star get this energy? What is the process by which two atoms fuse together called? (fusion) What is produced during fusion? (energy)
Now have students combine one deuterium atom and one hydrogen atom or proton.	How many protons does the atom that you have made contain? What do you suppose is given off when this reaction takes place in a star or the sun? (energy) What do you suppose this atom is called? (Students will probably not know. It is our isotope of helium or light helium.)
Now have students combine two models of light helium atoms.	How many protons does this atom contain? What element do you recognize? What would you have if you removed two protons? (helium atom) What do you think would happen to these two protons when this reaction takes place in the sun? Where could you find out?

Summary Statement: Stars may be formed when large clouds of hydrogen gas and dust come together under great pressure. Their source of energy is believed to come with fusion of hydrogen atoms into helium atoms with a release of energy.

Concept Terms: deuterium, light helium

Auxiliary Words: fusion, isotope

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